EXECUTIVE SUMMARY

NEW BRUNSWICK SOLID WASTE TRANSPORTATION STUDY

SUBMITTED TO:
SANITARY ENGINEERING SECTION
ENVIRONMENTAL PROTECTION BRANCH
DEPT. OF MUNICIPAL AFFAIRS & ENVIRONMENT
PROVINCE OF NEW BRUNSWICK

FEBRUARY 1988

ADI Limited
Engineers, Architects, Planners,
Management Consultants, Surveyors

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89-05747/

EXECUTIVE SUMMARY
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1.0 INTRODUCTION

Few issues have created more public controversy and distrust in New Brunswick than the collection, treatment and disposal of solid waste material. Most of the furor has occurred within the last ten years, fueled by a number of sensational disasters in the United States and elsewhere.

The causes for the controversy are not hard to find. Prior to 1986, most waste disposal sites in the Province were public dumps. Often these dumps were located at sites of convenience--within easy driving distance of population centres, but far enough away from homes to minimize nuisance impact. The sites were often old gravel pits, quarries or gulleys, selected with little thought to groundwater pollution, proliferation of pests, odour, or fire or safety hazards. As dumps, the sites received little maintenance or operations control.

Now conditions have changed. The Province, through the Department of Municipal Affairs and Environment (DMA&E), has committed itself to providing environmentally sound, state-of-the-art waste disposal facilities at a reasonable cost. To this end, DMA&E has identified 14 solid waste regions, each of which will be administered by a solid waste commission. Serving an average area of 2000 square kilometres, the 14 commissions will cover the majority of the Province's population and be responsible for the safe, environmentally acceptable disposal of solid wastes.

However, improved disposal has resulted in increased requirements for solid waste transportation. The old network of many, widely-scattered, small dumps has been replaced by a system of few, centrally located, large disposal sites. Access to the disposal sites is limited because of operations constraints. Thus solid waste transport has become a major factor in the location and operation of a solid waste disposal system.

Key issues in solid waste transport include:

(a) cost to commissions
(b) cost to hauler
(c) cost to solid waste generator
(d) ease of access to landfill
(e) effect upon existing road system
(f) requirements for new or upgraded roads to landfill site(s)
(g) highway safety (for collection truck and other vehicles)
(h) vehicle standards (safety, capacity, crew size)
(i) importance of competition among haulers
(j) scheduling
(k) quality of service
(l) method of payment (by waste generator, to hauler).

This study deals primarily with three major issues: the development of a microcomputer based model for evaluating the various costs associated with the transport of solid waste (domestic waste in particular) from the point of collection at the household to final delivery to the central disposal site; the development of policy guidelines for evaluating economic contracting options, primarily related to choosing negotiated or tendered contract procedures for domestic waste collection services in rural areas of the province; and the development of guidelines relating to the various safety aspects associated

with the waste collection operation including personnel safety, vehicle safety, road and street safety considerations and off-highway operation.

2.0 SOLID WASTE AND TRANSPORTATION (SWAT) MODEL

The general approach has been to develop a computer-based transportation model (SWAT Model) to evaluate the economic implications of choosing a central solid waste disposal site out of a number of potential sites as defined by constraint mapping (minimizing social and environmental impacts) and/or the centre of generation of the solid waste (based primarily upon centres of population and weighting to account for distances to the central disposal site). This is a prescreening procedure to define a single central disposal site; any further planning for particular local (rural) collection systems is then based upon this one central solid waste disposal site. Comparisons of various local collection system options is then made to determine the most economic method of rural collection. Twenty collection options are evaluated in terms of the collection cost, loading/unloading costs and line haul costs. The site evaluation and transportation costing procedures are presented in a simplified flow chart in Figure 1.

2.1 Central Solid Waste Disposal Site

As indicated in Figure 1, the first step is a prescreening process to determine the most economical central disposal site through a transportation costing analysis. This includes both an analysis of vehicle operating costs and infrastructure improvement costs. The vehicle operating costs include the typical cost components: fuel, oil, tires, maintenance repair, depreciation and value of time. The infrastructure improvements for the prescreening procedure include the costs for building

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SIMPLIFIED METHODOLOGY

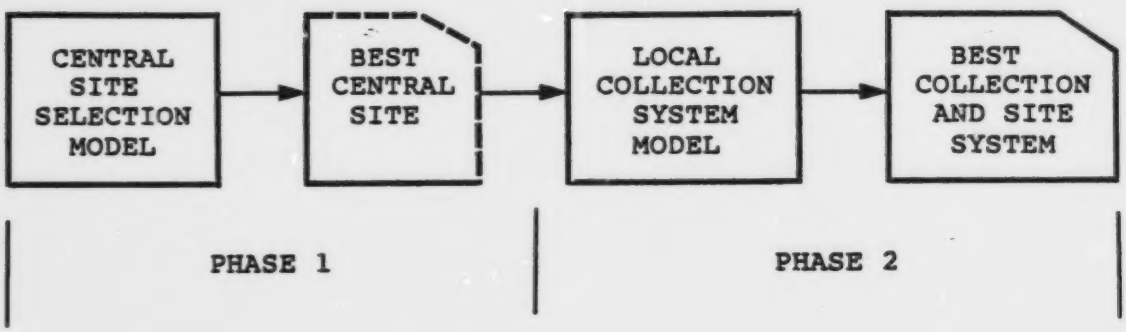

FIGURE 1: SIMPLIFIED METHODOLOGY FLOW DIAGRAM

accesses and access roads to each of the potential central solid waste disposal sites, and any upgrading costs required on existing highways and roads. Construction costs include all the components: right-of-way, grading, paving, bridges and drainage pipes/culverts.

Figure 2 shows the basic concept that is applied when determining the central solid waste disposal site. It is assumed that central solid waste disposal sites will be located within Regional Commission areas. Therefore, the central disposal site will be defined within the boundaries of the Commission area. Figure 2 depicts this graphically. The population centres, P1 through P6, are really the centroids of generation of the solid waste. P6 is shown as a rural area inside the Commission area, and again is treated as a population centroid. For the purposes of defining distances to the potential solid waste disposal sites, denoted as CDS_1 through CDS_4, the population centroids are considered the point of origin for the solid waste.

In terms of minimizing the total transportation costs within the Commission area, the line haul costs (from each population centroid to disposal site) are accumulated for each of the potential central disposal sites. The site with the minimum accumulated transportation costs is considered the optimum site.

2.2 Local (Rural) Collection Systems

As was indicated in Figure 1, phase 2 of the methodology concentrates upon determining the best local collection system once the central solid waste disposal site has been determined.

In terms of the physical rural collection system, there are three basic options to be considered. They include:

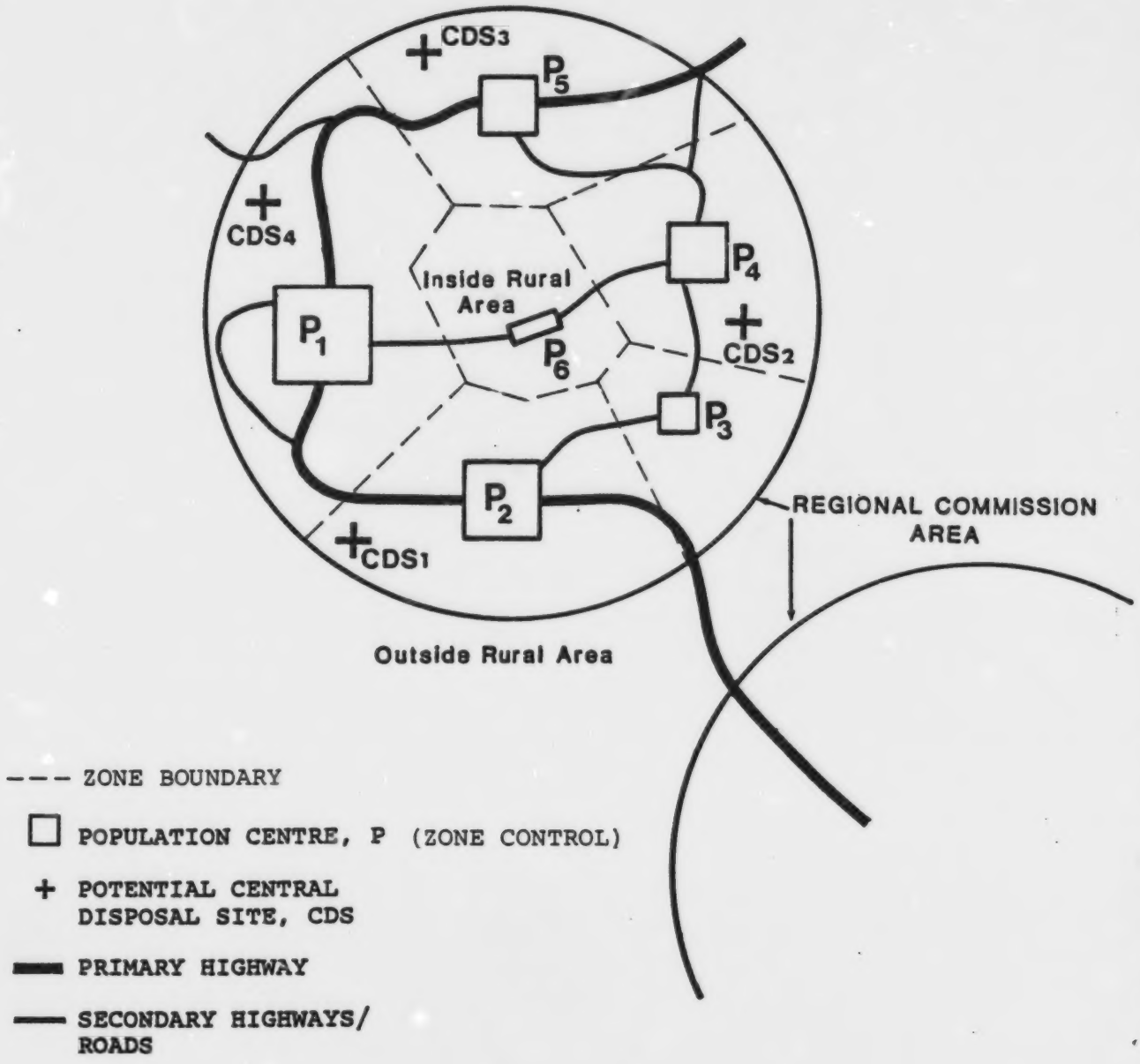

FIGURE 2: BASIC CONCEPT FOR CHOOSING THE CENTRAL SOLID WASTE DISPOSAL SITE WITHIN A COMMISSION AREA

- Household user delivery;
- Door-to-door pickup service; and
- Container sites and/or transfer stations.

The SWAT Model actually includes 20 options for rural garbage collection inside or outside the Regional Commission area. These options are really sub-options or some combination of the above three alternatives. Specific details of these 20 options are presented in Figure 3.

Each of the 20 rural collection system options are evaluated on the basis of the following factors:

- system equipment capital costs;
- system vehicle operating costs;
- system manpower requirements;
- zonal population served;
- zonal population density;
- collection rates and times;
- disposal site delivery distances;
- loading and unloading times;
- vehicle, container and transfer station capacities; and
- vehicle, container and transfer station capacity utilization.

The above evaluation is done for each zone or serviced area within or external to the Regional Commission area. From a transportation costing point of view, the most appropriate collection system for a particular zone is the least cost system. The SWAT Model computes the annual costs per option by summing the appropriate combination of system component costs:

1. Roadside collection component costs:
    a) collection costs;
    b) line haul costs;
    c) unloading costs.

MODEL 2/3: SOLID WASTE COLLECTION SYSTEM OPTIONS

OPTION 1: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - direct haulage to disposal site.

OPTION 2: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - direct haulage to disposal site.

OPTION 3: Curbside collection by 25 cy Side-Load Compaction vehicle with 8.50 te capacity - direct haulage to disposal site.

OPTION 4: Curbside collection by 25 cy Rear-Load Compaction vehicle with 9.07 te capacity - direct haulage to disposal site.

OPTION 5: Individual household - direct haulage to disposal site.

OPTION 6: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - haulage to container site with 3 20 cy Non-Compaction Roll-On/Roll-Off Containers with 2.00 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 20 cy size container.

OPTION 7: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - haulage to container site with 3 40 cy Non-Compaction Roll-On/Roll-Off Containers with 3.99 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 8: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - haulage to container site with 3 40 cy Non-Compaction Roll-On/Roll-Off Containers with 3.99 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 9: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - haulage to container site with 3 40 cy Compaction Roll-On/Roll-Off Containers with 12.70 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 10: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - haulage to container site with 3 40 cy Compaction Roll-On/Roll-Off Containers with 12.70 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 11: Individual household - haulage to container site with 3 8 cy Non -Compaction Dump Containers with a site capacity of 2.40 te - haulage to disposal site by 25 cy Rear-Loading Compaction Container Dumper with a 10.20 te capacity.

OPTION 12: Individual household - haulage to container site with 5 8 cy Non -Compaction Dump Containers with a site capacity of 4.0 te - haulage to disposal site by 40 cy Front-Loading Compaction Container Dumper with a 10.88 te capacity.

OPTION 13: Individual household - haulage to container site with 3 20 cy Non-Compaction Roll-On/Roll-Off Containers with 2.00 te capacity -haulage to disposal site by tilt-frame truck capable handling up to 20 cy size container.

OPTION 14: Individual household - haulage to container site with 3 40 cy Non-Compaction Roll-On/Roll-Off Containers with 2.49 te capacity -haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 15: Individual household - haulage to container site with 3 40 cy Compaction Roll-On/Roll-Off Containers with 2.00 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 16: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 17: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 18: Curbside collection by 25 cy Side-Load Compaction vehicle with 8.50 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 19: Curbside collection by 25 cy Rear-Load Compaction vehicle with 9.07 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 20: Individual household - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.05 te.

FIGURE 3

2. Household user delivery costs; and

3. Transfer component costs:
   a) container line haul costs;
   b) container loading/unloading costs;
   c) transfer station line haul costs;
   d) transfer station load/unloading costs.

3.0 POLICY GUIDELINES - ECONOMIC CONTRACTING OPTIONS

In the Fredericton region, the Department of Municipal Affairs and Environment negotiated three year contracts with local haulers for collection of waste in the rural areas within the commission boundaries. A number of concerns were raised as a result of this exercise, and the Province is interested in determining the direction future commissions should take in regard to rural collection. To address this issue, two basic options were examined: (i) negotiating a price with existing haulers, or (ii) call tenders for the collection services.

3.1 Recommended Policy Guidelines

Municipalities are responsible for their own domestic waste collection services; therefore the following policy guideline recommendations for choosing the type of contract for collection services are primarily applicable to the rural areas. The basic objective in either case is to decide whether to negotiate contracts or call tendered contracts.

General Contracting Restrictions

One major determinant of the type of contract to be implemented should be the analysis of the solid waste transportation costs and collection options evaluation. The solid waste and transportation (SWAT) model can be used to cost the various collection options available to an area (or zone) within a Regional Commission or external to the commission. The SWAT model is not intended to cost the options to an accuracy that one could predict exactly what a negotiated or contracted collection cost should be, but should provide a relative comparison of options. This then should indicate whether the collection system presently being used by a contractor (private hauler, negotiated or tendered contractor) is the most cost-effective.

Negotiated Contracts

Negotiate with existing waste collectors where:

Type I - existing haulers originally won a tendered or negotiated contract

1) If existing collection cost per capita per year is equal to or less than the average cost being experienced for the household density found in similar areas of the province;

2) Where the negotiated rate increase per capita does not exceed the inflation rate; the total contract price might be higher to account for new and future housing development in the serviced area;

3) If there are a sufficient number of existing haulers to service all areas with an acceptable quality of service; that is, they must be willing to service

the very low density areas as well as the high density areas with the same level of service and with the proper equipment.

Type II - existing haulers who originally developed the business by contacting individuals on their own and agreeing on a collection rate between them

1) If existing collection cost per capita per year is equal to or less than the average cost being experienced in other areas with similar household density; existing haulers must be willing to reveal their existing rates per capita;

2) Where the negotiated rate does not exceed the inflation rate and the final contract price allows for new and future housing development that is proposed for the contract period;

3) Where the existing hauler has a good track record for providing an acceptable quality of service and using the proper equipment to do the job properly and there have been a minimal number of complaints; and

4) If the existing hauler presently services 75 percent or more of the households in the area and is willing to service the remaining households at the same rate or better per capita as he presently charges plus an amount less than or equal to the present inflation rate.

Tendered Contracts

Tendered contracts should be called where:

Type I - one tendered contract or a substantially reduced number of tendered contracts will be arranged to service all the rural area(s)

1) Where the rural areas are not presently served by any waste collectors and the density is such that different areas have to be combined to make any waste collection system economically viable;

2) Where existing areas are being served by more than one collector and when combined because of gains in collection efficiency make the competitive bidding procedures feasible; and

3) If the collection system determined to be best for the area (e.g., using the SWAT model) requires that the existing collection system be replaced and the existing collectors are not in a position to meet the new collection requirements.

Type II - separate tendered contracts are called for smaller rural areas

1) Where the household density and total number of houses to be serviced is relatively high and there is existing competition for the domestic waste collection services through different private haulers (who presently may be servicing different routes, but in essence are really servicing the same area);

2) Where the negotiated prices would be higher than the average cost experienced in other areas of similar density and total market;

3) If there have been a number of complaints with respect to the quality of service being provided; and

4) If the existing haulers do not conform to provincial regulatory requirements nor meet safe operational requirements as generally found acceptable to the Department of Municipal Affairs and Environment.

4.0 SAFETY CONSIDERATIONS RELATED TO SOLID WASTE COLLECTION

An integral part of the provincial waste management program involves the collection of domestic waste in the rural areas of the Province of New Brunswick, inside and outside Regional Commission areas. As a result, serious consideration must be given to identification of existing and potential safety problems, particularly when, in many cases, posted speeds are 70 or 80 kilometres per hour or more.

Curbside or roadside solid waste collection operations can be defined as work activities where workers and equipment move along the road or street at a very slow speed with intermittent stops made at each household for actual collection of the waste. This is basically a short-term utility operation; however, as it occurs in the travelled lane every effort must be made to warn other traffic of the hazardous situation.

4.1 Vehicle Operation and Safety Recommendations

The domestic waste collection operation is potentially hazardous and with the relatively low speed and frequent stops, it is imperative that other drivers, particularly those approaching from the rear, have the earliest and most effective warning.

The safety recommendations are:

1. Rotating beacons/flashers be provided both at the front and back of the solid waste collection vehicle;

2. While in the actual process of collecting domestic waste, the four-way flashers be operated as well (since they are one of the most effective ways of alerting drivers to a slow-moving or stopped vehicle);

3. The slow-moving vehicle sign be attached to the vehicle in accordance with Regulation 84-98 under the New Brunswick Motor Vehicle Act.

In the actual operation of the vehicle, all the rules of the road according to the Motor Vehicle Act and related regulations be adhered to and refrain from using the vehicle for collection on the wrong side of the road or zig-zagging from one side of the road to the other. Collection should be made in the direction of the traffic flow. All loads of domestic waste should be adequately covered to prevent unlawful spillage or loss of load.

4.2 Personnel Operational and Safety Requirements

Domestic waste collection vehicles and the associated activity related to the roadside collection process actually has two basic hazards involved. One is the slow-moving or stopped

vehicle itself, but the other is the activity related to the crew members themselves. The workmen, as part of their duty, must be behind the collection vehicle to put the collected waste into the truck; this inherently puts these workmen in a high risk, hazardous position. Therefore, their dress, mannerism and activities while carrying out their duties must be carefully planned to maximize their safety.

As previously discussed, it is felt that the workmen should wear safety hats and safety footwear because they are working with mobile equipment (waste collection vehicles) and are loading the collection trucks with varied types of waste. The safety hats not only protect the workmen from potential head injuries but help to alert other drivers to their presence and nature of their activity. Although not specifically required by any Act or Regulation to date, it is recommended that the collection personnel all be required to wear a (fluorescent red or orange) safety jacket to identify them as workmen carrying out their duties in the roadway.

Safety equipment is not meant to free the workman of any responsibility for watching for traffic. Their own alertness is critical and responsible actions are required at all times. By the very nature of their duties they have to turn their backs to the traffic while putting waste into the collection truck. However, once the garbage is in the truck they should observe the traffic situation before making any sudden moves. Specifically, they should not be crossing to the other side of the road to pick up garbage. Domestic waste collection should be carried out on one side of the road at a time and in the same direction as the traffic flow.

On larger operations, in particular, it is recommended that safety policies be defined by the collection contractor. This would include establishing a safety committee and training programs in safety practices. For smaller contractors, the general safety guidelines and policies developed by the Department of Municipal Affairs and Environment could be used. All contractors would obviously have to adhere to any existing and future safety regulations provided for under the Motor Vehicle Act and Occupational Health and Safety Act or any other Provincial Acts and Regulations.

4.3 Road/Street Geometric Considerations

The highway and street geometries and posted speed can play a critical role in the safety of domestic waste collection. Even if the recommended safety practices were to be put in place for the waste collection vehicle and personnel, there still remains particular hazards that are characteristic of the roadway. They require particular attention and consideration by the collection crew.

Sharp curves pose a particular hazard, most notably in the rural areas of the province. Under such conditions collection vehicles should be operated on, or as close as possible to, the shoulder. If at all practical, the collection vehicle should remain at the beginning of the curve while the collection crew carry the solid waste to the collection vehicles. In very dangerous situations, warning signs should be placed at the beginning of the sharp curve(s). This may be the only safe alternative where there is a limited shoulder combined with a sharp, blind curve. This is particularly hazardous if the posted speed is 70 to 80 kilometres per hour or more. Blind knolls are really sharp vertical curves posing much of the same hazard as the aformentioned sharp horizontal curves. In addition, they may have relatively steep grades associated with

them. The aforementioned safety practices should again be applied in these circumstances. In addition, one of the crew may have to act as flagman in these hazardous areas of the route.

Winter conditions pose other types of hazards. Because domestic waste collection vehicles are operating at very slow speeds and stop frequently on the roadway, they should not be operated on icy, slippery roads, and particularly where sharp curves and steep grades are involved. The collection operation should be delayed until the road is salted and/or sanded. This will probably affect the collection contractor's schedule, but safety considerations must come first.

Generally speaking, highways and roads with the higher speeds have the better geometrics (lower grades, smoother curves, better sight distances) and a relatively good, wide shoulder. The waste collection operation on highway speed highways and roads should be carried out on the shoulder. The majority of highways in New Brunswick are two-lane, bi-directional roadways so that there is no lane free for a lane change if the waste collection vehicle occupies the travelled lane. This forces other traffic to make a passing maneuver, perhaps where a solid line exists. Locations where the collection vehicle must operate in the travelled lane may require that one of the crew temporarily act as a flagman until operations can continue on the shoulder.

Safe operations must be maintained at intersections and railway crossings. A collection vehicle does not have special privileges and therefore must obey the rules (law) of the road. All collection of waste must be completed prior to both the collection vehicle and crew passing through an intersection. At

railway crossings the vehicle should not be stopped near or on the tracks while the workmen collect and dump the garbage into the truck.

It should be noted that the responsibility for safe operations lies with both the contractor and the personnel he has collecting the domestic waste. The size of the operation should not be relevant to the degree of the safety required. Small open trucking operations should follow the same safety practices as larger, compactor trucking operations.

4.4 Off-Highway Considerations

Off-highway waste collection operations are as important from the safety perspective as are road and street collection practices. There may be the attitude that once they leave the public road or street the collection crew can relax their safety procedures. However, in some respects there are more variables with which the crew must contend.

Container site operations is one area where the waste collection vehicle must be operated safely as on the highway, because the public are free to use the site at any time. Therefore, public and private vehicles may be at the container site at the same time. Alertness to the surrounding vehicles and persons at the sight must be maintained. The collection vehicle is often operated in reverse and the collection crew are carrying out a number of duties, all of which should be coordinated to ensure the safety of the crew and public. Operation of safety equipment should be maintained during these operations. Potentially some smaller container sites could be located in or near service stations, convenience stores or similar areas where the amount of other vehicular and pedestrian activity could be considerable. It is the responsibility of the collection crew to ensure

that they carry out their duties in a safe manner at all times. The crew and driver should be courteous and respectful of other vehicles and drivers, and follow the rules (law) of the road while off the road and when reentering the main traffic stream.

FINAL REPORT

NEW BRUNSWICK SOLID WASTE TRANSPORTATION STUDY

SUBMITTED TO:
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Project 1852-2

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RE: NEW BRUNSWICK SOLID WASTE TRANSPORTATION STUDY

ADI Limited is pleased to submit twenty-five (25) copies of our Final Report and Executive Summary on the New Brunswick Solid Waste Transportation Study. The report has been divided into three sections, each addressing a particular study objective. Section 1 deals with the Solid Waste and Transportation (SWAT) Computer Model. Section 2 presents a set of Policy Guidelines for Economic Contracting Options. Finally, Section 3 addresses Safety Considerations Related to Solid Waste Collection.

Thank you for the opportunity to work with you and your staff on this project.

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T. R. HOLYOKE, M.Sc., ENG.

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SECTION 1

SOLID WASTE AND TRANSPORTATION (SWAT) MODEL

1.0 SOLID WASTE AND TRANSPORTATION (SWAT) MODEL

1.1 Introduction

Few issues have created more public controversy and distrust in New Brunswick than the collection, treatment and disposal of solid waste material. Most of the furor has occurred within the last ten years, fueled by a number of sensational disasters in the United States and elsewhere.

The causes for the controversy are not hard to find. Prior to 1986, most waste disposal sites in the Province were public dumps. Often these dumps were located at sites of convenience--within easy driving distance of population centres, but far enough away from homes to minimize nuisance impact. The sites were often old gravel pits, quarries or gulleys, selected with little thought to groundwater pollution, proliferation of pests, odour, or fire or safety hazards. As dumps, the sites received little maintenance or operations control.

Now conditions have changed. The Province, through the Department of Municipal Affairs and Environment (DMA&E), has committed itself to providing environmentally sound, state-of-the-art waste disposal facilities at a reasonable cost. To this end, DMA&E has identified 14 solid waste regions, each of which will be administered by a solid waste commission. Serving an average area of 2000 square kilometres, the 14 commissions will cover a majority of 75 percent of the Province's population and be responsible for the safe, environmentally acceptable disposal of solid wastes.

However, improved disposal has resulted in increased requirements for solid waste transportation. The old network of many, widely-scattered, small dumps has been replaced by a system of few, centrally located, large disposal sites. Access to the landfill sites is limited because of operations constraints. Thus solid waste transport has become a major factor in the location and operation of a solid waste disposal system.

Key issues in solid waste transport include:

(a) cost to commissions
(b) cost to hauler
(c) cost to solid waste generator
(d) ease of access to landfill
(e) effect upon existing road system
(f) requirements for new or upgraded roads to landfill site(s)
(g) highway safety (for collection truck and other vehicles)
(h) vehicle standards (safety, capacity, crew size)
(i) importance of competition among haulers
(j) scheduling
(k) quality of service
(l) method of payment (by waste generator, to hauler).

Because of the increased importance of transportation issues in solid waste disposal, the Department of Municipal Affairs and Environment contracted out this study of domestic waste transportation. The study deals primarily with three major issues: the development of a microcomputer based model for evaluating the various costs associated with the transport of solid waste (domestic waste in particular) from the point of collection at the household to final delivery to the central disposal site; the development of policy guidelines for evaluating economic contracting options, primarily related to choosing negotiated or

tendered contract procedures for domestic waste collection services in rural areas of the province; and the development of guidelines relating to the various safety aspects associated with the waste collection operation including personnel safety, vehicle safety, road and street safety considerations and off-highway operation.

As per the Terms of Reference prepared by the Department of Municipal Affairs and Environment the study has met the following five specific objectives:

Objective 1. Develop a transportation model or set of guidelines to be used to determine the best possible location for a central disposal facility by meeting the needs of commissions while minimizing transportation costs.

Objective 2. Determine costs for various waste collection options for use in regions not within commission areas.

Objective 3. Examine options for rural collection within commission boundaries.

Objective 4. Investigate safety aspects of waste collection in rural areas.

Objective 5. Develop guidelines to indicate when it is better to negotiate a contract for rural collection services and when it is best to call tenders for the contract.

1.2 Approach and Methodology - SWAT Model

Our general approach has been to develop a computer-based transportation model (SWAT Model) to evaluate the economic implications of choosing a central solid waste disposal site out of a

number of potential sites as defined by constraint mapping (minimizing social and environmental impacts) and/or the centre of generation of the solid waste (based primarily upon centres of population and weighting to account for distances to the central disposal site). This is a prescreening procedure to define a single central disposal site; any further planning for particular local (rural) collection systems is then based upon this one central solid waste disposal site. Comparisons of various local collection system options is then made to determine the most economic method of rural collection. Twenty collection options are evaluated in terms of the collection cost, loading/unloading costs and line haul costs. The site evaluation and transportation costing procedures are presented in a simplified flow chart in Figure 1.1.

1.2.1 Central Solid Waste Disposal Site

As indicated in Figure 1.1, the first step is a prescreening process to determine the most economical central disposal site through a transportation costing analysis. This includes both an analysis of vehicle operating costs and infrastructure improvement costs. The vehicle operating costs include the typical cost components: fuel, oil, tires, maintenance repair, depreciation and value of time. The infrastructure improvements for the prescreening procedure include the costs for building accesses and access roads to each of the potential central solid waste disposal sites, and any upgrading costs required on existing highways and roads. Construction costs include all the components: right-of-way, grading, paving, bridges and drainage pipes/culverts.

Figure 1.2 shows the basic concept that is applied when determining the central solid waste disposal site. It is assumed that central solid waste disposal sites will be located within

NEW BRUNSWICK SOLID WASTE TRANSPORTATION STUDY

SIMPLIFIED METHODOLOGY

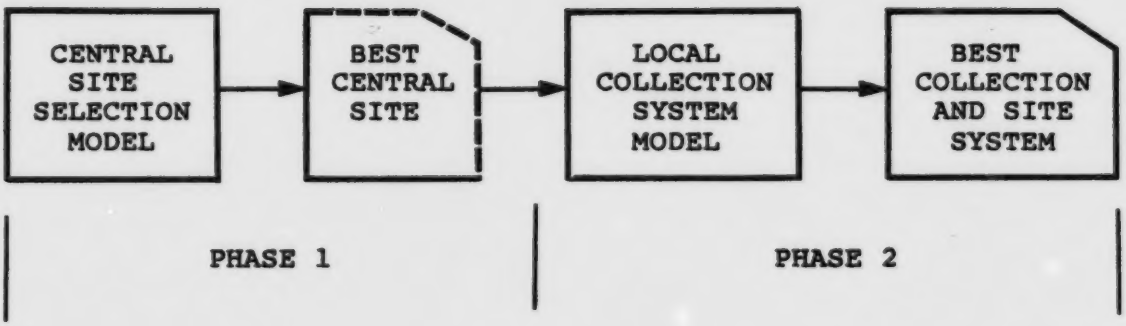


FIGURE 1.1: SIMPLIFIED METHODOLOGY FLOW DIAGRAM

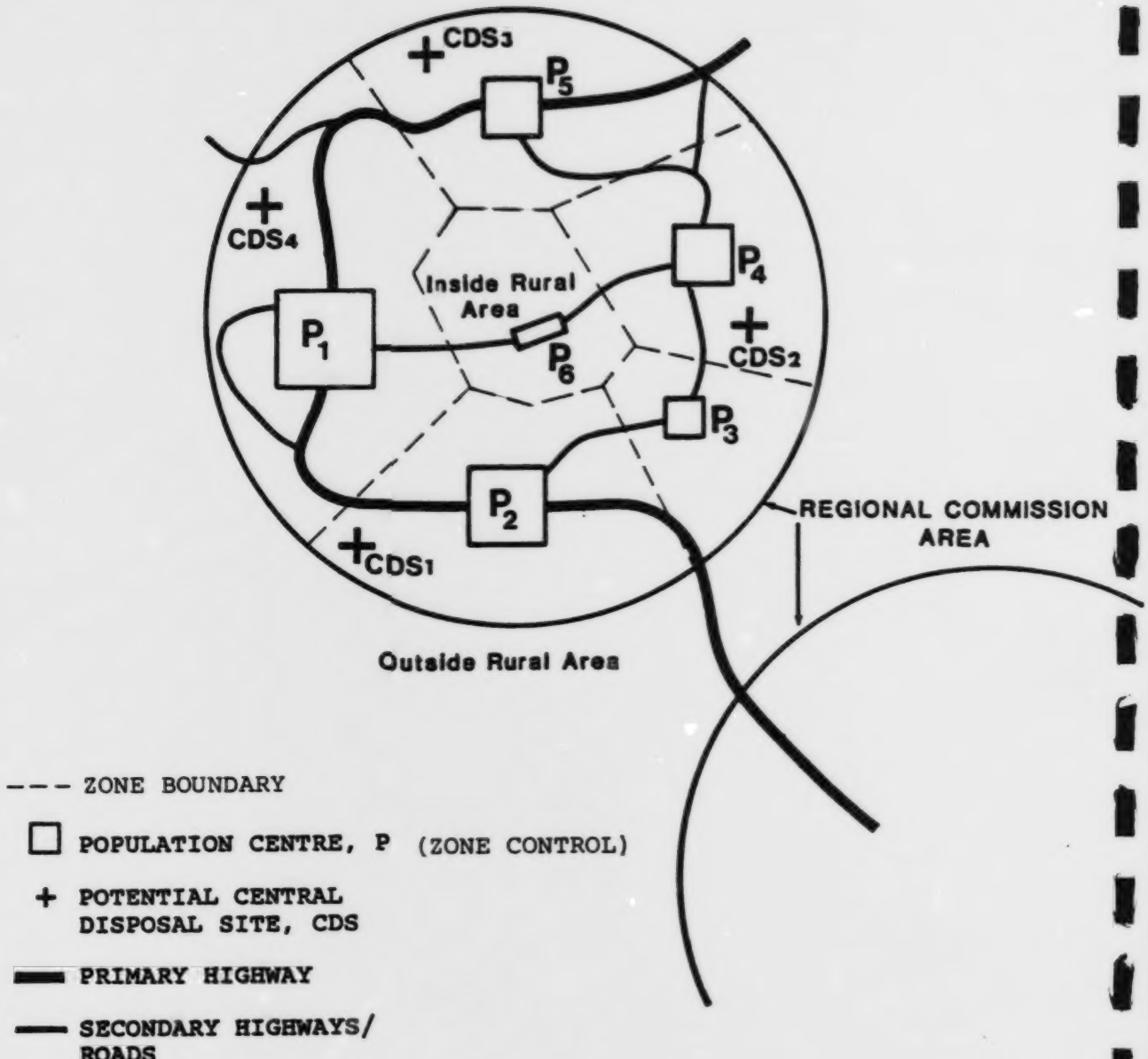


FIGURE 1.2: BASIC CONCEPT FOR CHOOSING THE CENTRAL SOLID WASTE DISPOSAL SITE WITHIN A COMMISSION AREA

Regional Commission areas. Therefore, the central disposal site will be defined within the boundaries of the Commission area. As depicted in Figure 1.2, the population centres, P1 through P6, are really the centroids of generation of the solid waste. P6 is shown as a rural area inside the Commission area, and again is treated as a population centroid. For the purposes of defining distances to the potential solid waste disposal sites, denoted as CDS_1 through CDS_4, the population centroids are considered the point of origin for the solid waste. For practical purposes and within the accuracy of the data available at this point, this provides the best measure of transporting distance.

In terms of minimizing the total transportation costs within the Commission area, the line haul costs are accumulated for each of the potential central disposal sites. Mathematically this is presented below:

$D_{P1\text{-}CDS_1}$ = distance, km, between population centroid, P_1, and proposed central disposal site, CDS_1;

$D_{P6\text{-}CDS_4}$ = distance, km, between population centroid, P_6, and proposed central disposal site, CDS_4.

TT_{P1} = number of truck trips generated annually by the population, P_1, and

$$TT_{P1} = \frac{P_1 \times \text{annual tonnes of solid waste generated per person}}{\text{tonnes of solid waste transported per vehicle}};$$

and

VOC_{P1-CDS_1} = vehicle operating costs (including driver, helper(s), overhead, equipment, fuel, etc. $/km) between population centroid, P_1, and proposed central disposal site, CDS_1; and similarly for VOD_{P2-CDS_1} through to VOC_{P6-CDS_4}.

SUMMARY OF TRANSPORTATION COSTS
PROPOSED CENTRAL SOLID WASTE DISPOSAL SITES

For the proposed central disposal site, CDS_1,

$VOC_{P1-CDS_1} \times TT_{P1} \times D_{P1-CDS_1}$ = total transportation cost for population, P_1

$VOC_{P2-CDS_1} \times TT_{P2} \times D_{P2-CDS_1}$ = total transportation cost for population, P_2

$VOC_{P3-CDS_1} \times TT_{P3} \times D_{P3-CDS_1}$ = total transportation cost for population, P_3

$VOC_{P4-CDS_1} \times TT_{P4} \times D_{P4-CDS_1}$ = total transportation cost for population, P_4

$VOC_{P5-CDS_1} \times TT_{P5} \times D_{P5-CDS_1}$ = total transportation cost for population, P_5

$VOC_{P6-CDS_1} \times TT_{P6} \times D_{P6-CDS_1}$ = total transportation cost for population, P_6

$$TTC_{CDS_1} = \sum_{i=1}^{6} VOC_{P_i-CDS_1} \times TT_{P_i} \times D_{P_i - CDS_1}$$ = total transportation cost for site, CDS_1

Similarly, for CDS_2,

$$TTC_{CDS_2} = \sum_{i=1}^{6} VOC_{P_i\text{-}CDS_2} \times TT_{P_i} \times D_{P_i\text{-}CDS_2}$$

for CDS_3,

$$TTC_{CDS_3} = \sum_{i=1}^{6} VOC_{P_i\text{-}CDS_3} \times TT_{P_i} \times D_{P_i\text{-}CDS_3}$$

and for CDS_4,

$$TTC_{CDS_4} = \sum_{i=1}^{6} VOC_{P_i\text{-}CDS_4} \times TT_{P_i} \times D_{P_i\text{-}CDS_4}$$

By forecasting the population growth within the Commission area over a twenty year planning period, one can extrapolate the above transportation costing model to cover a ten or twenty year planning period. A social discount rate of 10 percent (or any acceptable discount rate) can then be applied to the annual transportation costs to determine the present worth of the total transportation costs associated with each proposed central solid waste disposal site over the planning period.

In terms of the infrastructure costs associated with each site, any additional pavement thickness (pavement strengthening) or bridge replacements on existing highways and roads should be examined to ensure all-weather operation (including the spring weight restriction period). In addition, the cost of building new access roads has to be examined, including all right-of-way and construction costs. The total present worth of new construction and upgrading is then determined for all highways and roads related to each site.

With the present worth of transportation costs and highway infrastructure improvement costs determined, a cost-effectiveness analysis can be carried out to ultimately determine which

of the proposed central disposal sites is most appropriate. It should be noted that when one of the sites being proposed is based on the centre of generation of the solid waste, minmizing the transportation costs is inherently the determinant for that particular site location. Therefore, it would naturally be the best central disposal site from a transportation cost point of view. However, generally speaking, this type of site would have to be an engineered site (examples include incineration, imported base materials such as impermeable clays and/or synthetic liners) and thus more expensive than the standard sanitary landfill site. When a comparison is being made, including a central disposal site option based upon the centre of generation, then the costs should also include the disposal site development and operation costs, and then a cost-effectiveness evaluation made to determine the most economic site location. The site development and operational costs associated with the central disposal site are not included in the transportation costing model.

1.2.2 Local (Rural) Collection Systems

As was indicated in Figure 1.1, phase 2 of our methodology concentrates upon determining the best local collection system once the central solid waste disposal site has been determined. At this level of analysis, factors other than transportation costs and highway and road infrastructure costs play a part in choosing the final option. These factors include social considerations such as level-of-service, neighbourhood disruption, and relevant traffic problems and other more technical factors, including access problems, spring weight restrictions, routing, scheduling and safety.

In terms of the physical rural collection system, there are three basic options to be considered. They include:

- Household user delivery;
- Door-to-door pickup service; and
- Container sites and/or transfer stations.

The SWAT Model actually includes 20 options for rural garbage collection inside or outside the Regional Commission area. These options are really sub-options or some combination of the above three alternatives. Specific details of these 20 options are presented later in the Users Manual.

Each of the 20 rural collection system options are evaluated on the basis of the following factors:

- system equipment capital costs;
- system vehicle operating costs;
- system manpower requirements;
- zonal population served;
- zonal population density;
- collection rates and times;
- disposal site delivery distances;
- loading and unloading times;
- vehicle, container and transfer station capacities; and
- vehicle, container and transfer station capacity utilization.

The above evaluation is done for each zone or serviced area within or external to the Regional Commission area. From a transportation costing point of view, the most appropriate collection system for a particular zone is the least cost system. The SWAT Model computes the annual costs per option by summing the appropriate combination of system component costs:

1. Roadside collection component costs:
   a) collection costs;
   b) line haul costs;
   c) unloading costs.

2. Household user delivery costs.

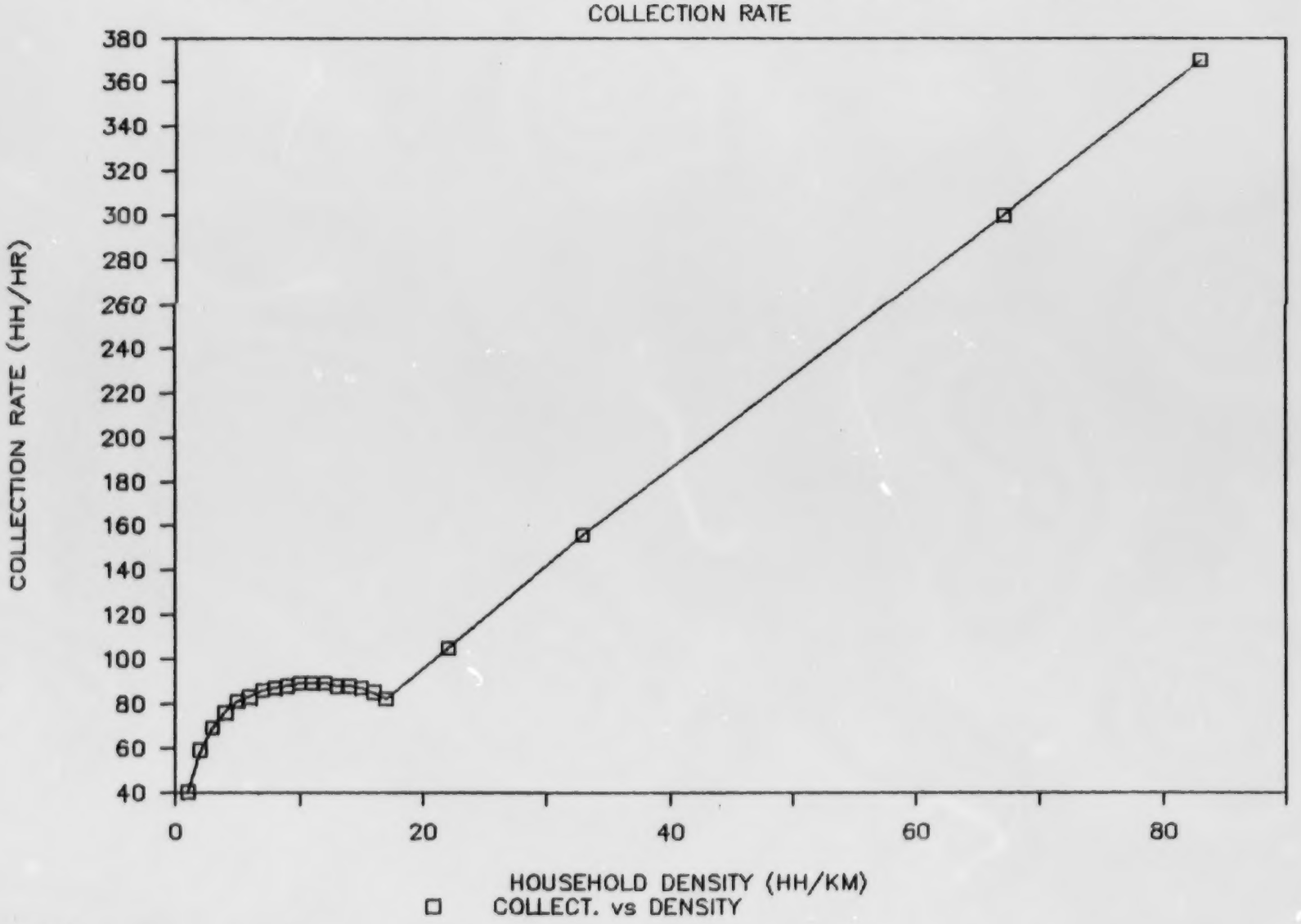
3. Transfer component costs:
   a) container line haul costs;
   b) container loading/unloading costs;
   c) transfer station line haul costs;
   d) transfer station load/unloading costs.

Further details relating to the above system component costs are presented in the Users Manual section of the report.

The general methodology applied to determining the roadside collection component costs was to allow for a certain collection rate based upon the household density in the area being serviced. The premise for the collection rate was, in simplified form, that where the population is sparse and the households are scattered with a very low density (households per kilometre) the actual collection rate (households per hour) is dependent not only on the speed of the workmen in physically collecting the garbage from the roadside to the waste collection vehicle, but also upon the speed of the collection vehicle when travelling between households. As the household density increases along a route then the collection rate increases because the workmen are spending more time actually collecting garbage and relatively less time travelling or walking. Figure 1.3 shows the relationship between collection rate and the household density along a serviced route. Up to about 17 households per kilometre the collection rate is a function of the productivity of the crew and the speed of the collection vehicle between households which is nonproductive time.

Figure 1.3

SOLID WASTE TRANSPORTATION MODEL



Beyond 17 households per kilometre the density is closer to the suburban and finally the urban situation and the collection rate becomes a function of the productivity of the crew only with relatively little nonproductive time. It is assumed that as the density increases the crew size increases accordingly to accommodate the additional workload. The actual data was taken from texts on solid waste management with consideration given to comments from individuals regarding productivity and operational characteristics of roadside collection of garbage. The rates are intended as average, representative rates only and are obviously dependent upon the efficiency of the crew and equipment being utilized.

The actual cost of collection is related to the total time it takes to fill the collection vehicle to capacity. The collection cost per vehicle load is then determined by multiplying the time to fill the vehicle by the unit operational cost per hour.

Details regarding the actual unit costs per vehicle hour are presented in the Users manual section. The line haul costs per load are then a function of the return haul distance to the central disposal site from the zone or collection area centroid and the unit operating costs per kilometre. If the collection vehicle (noncompaction) delivers to a container site instead then an average radius of operation of 8 kilometres (5 miles) is assumed and therefore an average return trip distance of 8 kilometres is assumed from collection site (or route) to the container site. It was found from discussions with various individuals involved in the operation of container sites in New Brunswick and Prince Edward Island that this is the approximate operational boundary for such sites. Where a transfer station is located in a particular zone, the line haul cost is determined in a similar manner to that for delivery directly to the central disposal site. The unloading costs per load are a

function of the time it takes to unload the collection vehicle at the central disposal site, container site or transfer station and the unit operating cost per hour. The actual unloading times for each vehicle were determined from discussions with individuals in the disposal business and equipment suppliers and are intended as only average times. The total collection cost per vehicle load is then the sum of the route collection costs, line haul costs and unloading costs. The total collection cost per week or year is then a function of the total number of trips required and the total collection cost per load. The total number of trips required is simply the total tonnes of garbage generated by the zonal population divided by the collection vehicle capacity.

Where household user delivery to the central disposal site is the option then the cost is derived by assuming delivery would be made once a week by each individual to the disposal site. The cost per trip per household is simply the unit operating cost times the return distance from the household to the disposal site. This distance is assumed to be the distance from the zone centroid to central disposal site and is assumed representative of the average distance to individual households within the zone. The total annual user delivery cost is then the product of delivery cost per trip, number of households in the zone and 52 weeks per year. Similar to roadside collection options, the household user may deliver to a container site or transfer station. Again, when container sites are used the radius of operation is assumed to be approximately 8 kilometres, resulting in an average return haul distance to the container site of 8 kilometres. Where a transfer station is used, the distance from the zone centroid to the transfer station location is used.

In any options where containers or transfer stations are used the transfer component costs are included in the total collection and transportation cost. This includes the line haul cost in moving the garbage from the container or transfer station to the central disposal site. This final delivery cost is a function of the vehicle (capacity) used to transfer the domestic waste and associated unit operating costs. The costs are adjusted to account for site development, access, construction and/or upgrading, and capital equipment so that both vehicle operating costs and infrastructure costs are accounted for in the final analysis.

In all cases, the ultimate goal is to transport the solid waste to the central disposal site at minimum cost, and at the same time, minimize the associated highway infrastructure costs and solid waste collection infrastructure costs. All these costs are included in our collection system analyses.

1.2.3 Qualitative Evaluation of Other Factors

In addition to the aforementioned quantitative transportation costs and infrastructure and operational costs, the previously identified qualitative factors including quality-of-service, neighbourhood disruption, relevant traffic problems and safety issues should be considered in the overall evaluation of collection system options. The qualitative analysis cannot be directly incorporated into the SWAT Model, but there needs to be a basic approach whereby the qualitative factors can be incorporated into the final analysis along with the quantified transportation and infrastructure costs. The following technique is presented as a general means to combine the quantitative and qualitative factors.

The general approach to the qualitative factors is to develop a scale of relative importance and/or impact. The social considerations, for example, could be rated according to a simplified scale similar to the following:

Very Good - implying a minimum impact, if any, in the positive sense;

Good - impact would be marginal;

Fair - impact would be significant, but acceptable;

Poor - impact would be detrimental to the existing social environments;

Very Poor - an extremely negative impact would result, implying that some other alternative should be found.

The actual scale, whether it be a qualitative description as presented here or a quantitative numeric scale ranging from 1 to 10, should be determined in consultation with the staff of the Environmental Protection Branch of the Department of Municipal Affairs and Environment. The number and type of factors will vary for each case study undertaken.

To some extent, some of the qualitative social and technical factors may conflict with one another. For example, in terms of level-of-service, door-to-door garbage collection could be considered ideal (that is, be assigned a qualitative rating of Very Good), but in terms of increasing neighborhood noise and disruption, might receive a rating of only fair, or possibly lower. Container service, on the other hand, would possibly receive a

rating of only Fair, in terms of level-of-service, while receiving a rating of Very Good in terms of neighborhood noise and disruption. These are intended as examples only and do not represent preconceived measures of importance of one factor relative to the other. Varying circumstances will result in quite different ratings.

Figure 1.4 is a graphical presentation of the suggested method of combining the qualitative factors and quantitative costs. The Base Line represents the line along which the collection options can be considered equivalently acceptable. Collection options that would have coordinates falling above the Base Line are considered less desirable and those with coordinates below the Base Line are considered more desirable. The Base Line is determined by first locating the coordinates of the overall average conditions. That is, determine the average annual cost per capita for waste collection service in the province to define the X-coordinate and determine the expected average qualitative rating for all collection options for the particular qualitative factor (e.g., quality-of-service) to define the Y-coordinate. Then draw the Base Line from the very poor rating along the Y-axis through the previously defined X- and Y-coordinates to intersect with the X-axis. The coordinates associated with each of the 20 options can then be plotted and compared to determine the more desirable collection system option.

The final transportation cost-effectiveness analysis should incorporate both the quantitative and qualitative results so that an acceptable and economical collection system can be determined.

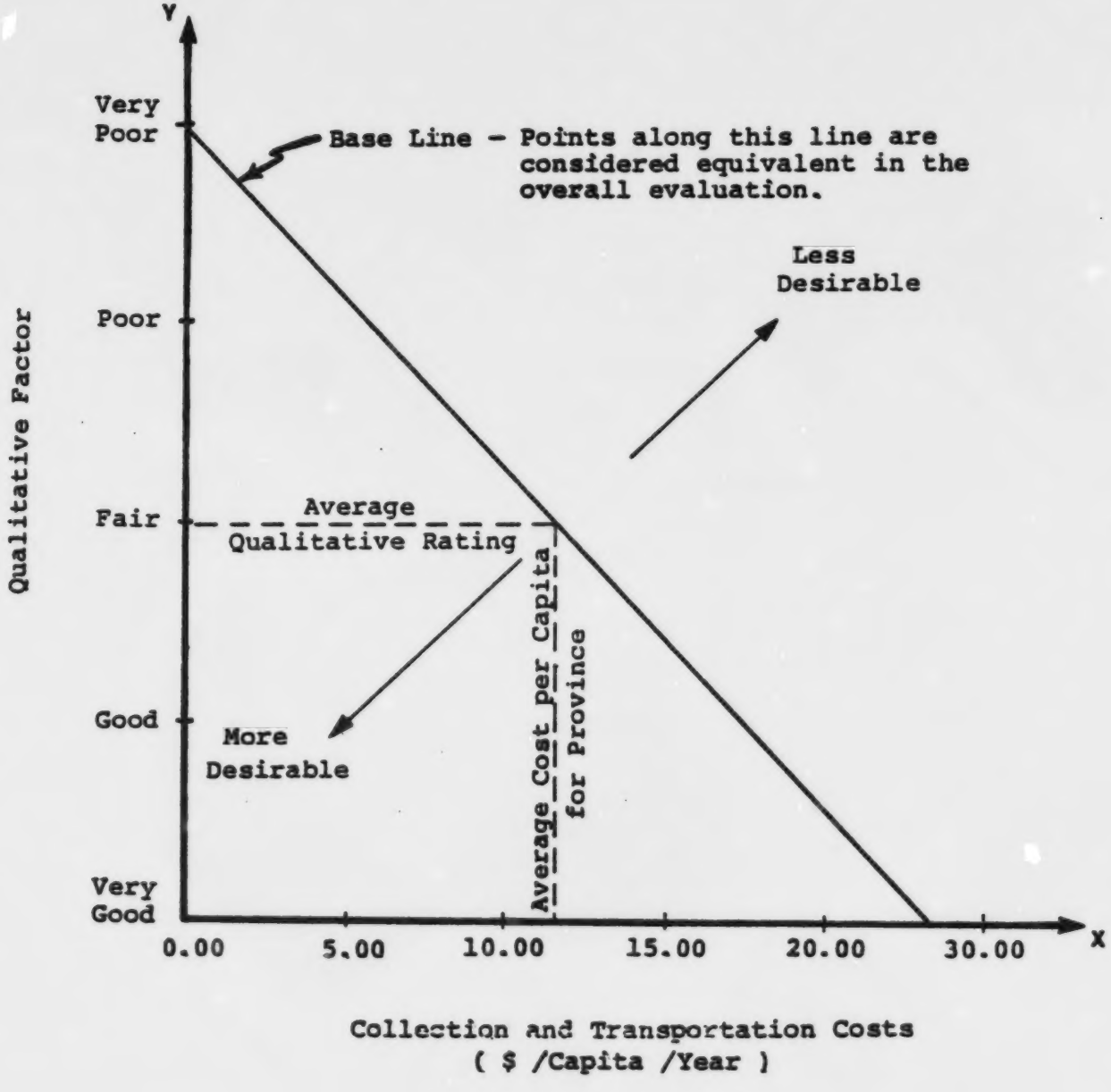


FIGURE 1.4 - Suggested Method for Combining the Qualitative Evaluation Factors and the Quantified Collection and Transportation Costs

1.3 Users Manual

The actual programming for the Solid Waste and Transportation (SWAT) Model is done in the APL programming language. Use is also made of the APL Spreadsheet Manager for data entry, display and management features for various parts of the model. Appendix I presents the flow chart for the SWAT computer program model. As can be seen in the flow chart, the basic structure of the computer program is the development of three primary programs:

1. Data Entry/Management Features for Compiling the Primary Databases;

2. Model 1 - Site Options Selection Analysis Programs; and

3. Model 2/3 - Collection System Options Evaluation Programs.

A fourth and intermediate feature for either or both of the Site Selection and Collection System models is the optional Population Forecasting Module.

This section of the report is not intended to be a computer programmer's manual; therefore, emphasis is placed upon the "user" and the need for a user's guide that is practical and functional without getting into the specifics of the model structure. Section 1.2 Approach and Methodology - SWAT Model presented the technical and analytical approach to the collection and transport of domestic solid waste in rural areas. It should be noted that, although the SWAT Model was developed for application to rural garbage collection, it is equally applicable to urban areas and in the actual application of the model, it is intended that all collection areas or zones be included in the analysis.

Figure 1.5 shows the SWAT Model Users Guide Flow Chart which represents a compressed version of the formerly presented SWAT computer program flow chart included in Appendix I. In brief, this flow chart guides the user through the various features of the SWAT Model. The main menu really represents only two major options: 1) run the main SWAT Model program; or 2) carry out various file management features provided for immediately upon entry into the program and exit from the SWAT Model program. Each of the features available within these two basic functions will be discussed more fully in the sections below.

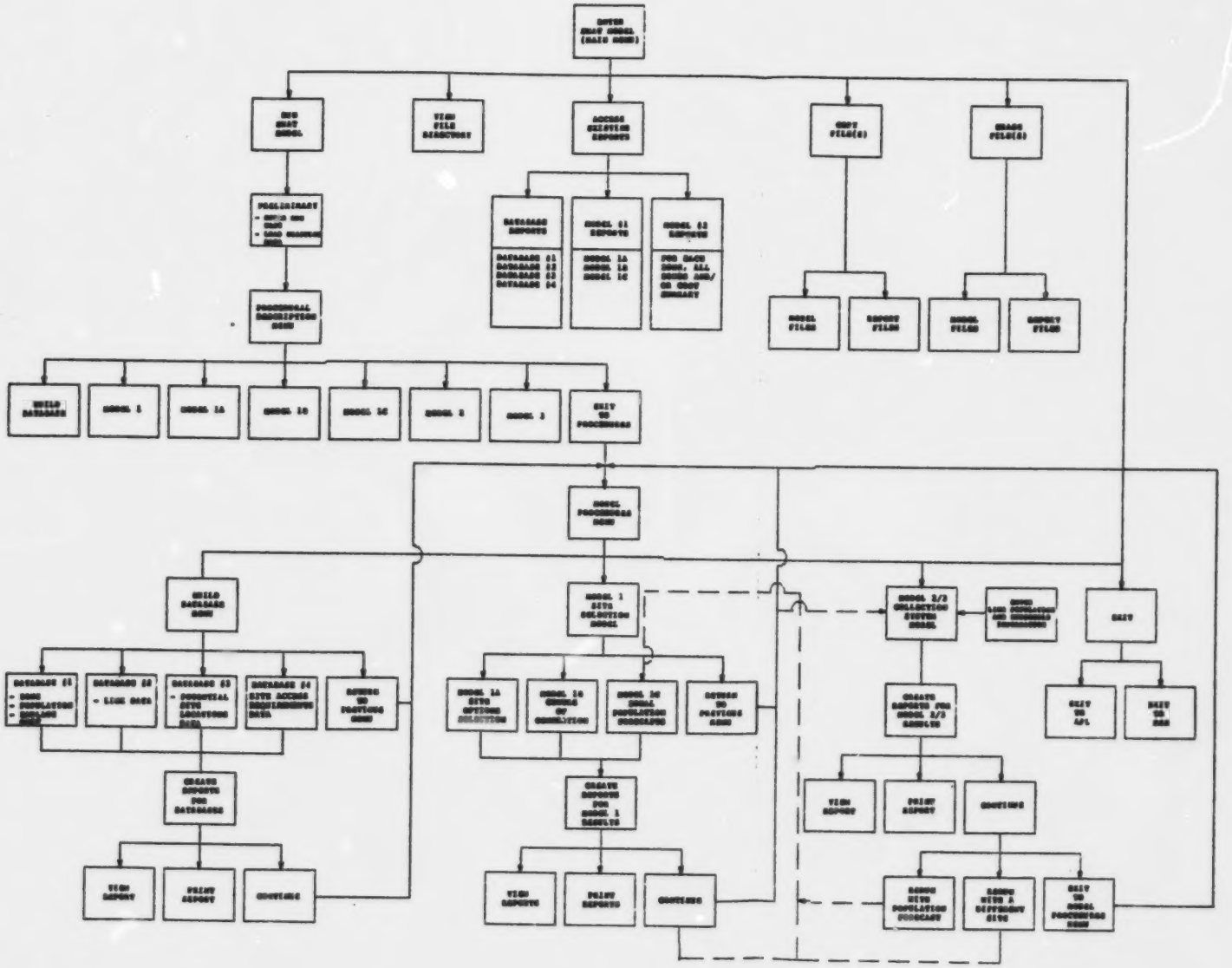
The most basic questions asked by users of any computer model are: How do I start the program, What do I do if I make a mistake, and How do I stop the program without losing all my hard work? Firstly, the assumption is made that the SWAT Model files have all been loaded onto a hard disk (of an AT-compatible microcomputer) under the same directory as the APL*PLUS programming language and related Spreadsheet Manager files. SWAT Model was developed using version 6.3 of APL*PLUS from STSC Incorporated and version 2.1.1 of Spreadsheet Manager from STSC Incorporated as well. SWAT Model may not run using earlier versions, particularly earlier versions of the Spreadsheet Manager.

To start the SWAT Model, simply type "SWAT" and press the RETURN or ENTER key. The user will then be presented with various instructions and menu options.

If, at any time, a mistake is made while running SWAT Model (e.g., you enter an incorrect number and have pressed the RETURN key), then press the CTRL and ESC keys together, then type "RESTART" and press the RETURN or ENTER key. It should be noted, however, that if you notice that you have made a data entry error prior to pressing the RETURN key, you can simply

FIGURE 1.5

SWAT MODEL USERS GUIDE FLOW CHART



back space using the BACK SPACE key and reenter the data. Otherwise, after typing "RESTART" and pressing RETURN, the SWAT Model program will start from the beginning. After restarting the user may, however, using a different RUN NAME, simply use the previous data files and then step through the various SWAT Model menus to the point at which the error was made. If the error was made while entering a particular database (using one of the procedures from the BUILD DATABASE menu) then that particular database will have to be reentered completely. This is why intermediate databases are automatically saved after data entry is completed for each particular database. If the error was made while running a particular model procedure (e.g., Model 1B - Centre of Generation), then that particular procedure will have to be rerun from the beginning, but databases or other model procedures which were run previous to making the error will not have to be rerun. In other words, you simply step through the various menus in SWAT Model to the particular database or model procedure in which the mistake was made and redo that particular database or model procedure from the beginning.

You may safely stop the SWAT Model program after the completion of any database or model procedure. You simply step through the menu(s) to an EXIT menu option. At this point, all SWAT Model files and Report files (as requested by the user) will have been saved. The user then is presented with the option of exiting to the active APL workspace or the MS DOS operating system. Upon exit to APL the user can load another APL workspace or use any of the other features of the APL programming language. Upon exit to the MS DOS operating system the user can use any of the DOS commands available, start any other microcomputer programs or turn the microcomputer off. All files, as previously stated, will have been saved under the RUN NAME chosen by the user at the preliminary stages of running SWAT Model.

1.3.1 Building Databases/Database Management/Reporting

Upon entry to the SWAT Model the user is presented with the Title Screen with the Message "***type "ENTER" to proceed****". The user simply presses the RETURN or ENTER key to continue to the main SWAT Model menu. Note that RETURN and ENTER are used interchangeably throughout this manual. They represent the same key on the keyboard, but different manufacturers use one name or the other or possibly the symbol ↵ to depict the data entry key.

A sample printout is presented in the Appendix II. The user can refer to this printout while following through this guide.

The main SWAT Model menu presents the user with the following options:

ENTER:
1. To run SWAT Model
2. To view file directory
3. To access existing reports
4. To copy a file
5. To erase a file
6. To exit

The user simply types their choice (e.g., "1" to run SWAT Model) and presses the ENTER key. Refer to Figure 1.5, the SWAT Model main menu to see where you are in the whole scheme of the model.

Data Management and Reporting

Options 2 to 5 are actually Data Management and Reporting procedures. The user will find that a number of files can be created fairly quickly when running SWAT Model, particularly if they make a number of separate runs for the same job or project.

This latter situation is usually the case simply because data entry and running model procedures are done in separate steps or stages. The SWAT Model is designed to protect files created under each run by storing them under the RUN NAME and each time the SWAT Model is run a new RUN NAME is required. During each run "M"odel files (that is, database files) are stored and "R"eport files (as requested by the user) are stored. It is up to the user to keep track of the latest RUN NAME (that is, the last run of SWAT Model) and to maintain some kind of order to the SWAT Model runs that are made. To assist in this the VIEW FILE DIRECTORY, option 2, is provided whereby the user is presented with a list of the various files that have been created. This list is presented on the microcomputer, monitor screen. After VIEWing the files (actually a list of the various run names that have been used during SWAT Model computer runs), the user is returned to the main SWAT Model menu.

Option 3 allows the user to ACCESS EXISTING REPORTS. The user is given the choice between accessing either "M"odel database reports or "R"eports generated by the model procedures (that is, results generated by running Model 1 or Model 2/3). When either of these is chosen the appropriate list of files are presented to the user on the monitor. The user chooses one of the existing file names. Then the user is asked which of the particular reports they want to VIEW on the screen or PRINT on the monitor. The options under ACCESS EXISTING REPORTS are:

ENTER 0 FOR DATABASE REPORTS
1 FOR MODEL #1 REPORTS
2 FOR MODEL #2/3 REPORTS

Subsequently, the sub-options under each of these are:

Under Database Reports:

ENTER 1 FOR DATABASE #1: ZONE, POPULATION AND HAULAGE COSTS
2 FOR DATABASE #2: LINK DATA
3 FOR DATABASE #3: SITE LOCATION
4 FOR DATABASE #4: SITE ACCESS REQUIREMENTS

Under Model #1 Reports:

ENTER 1 FOR MODEL 1A: SITE SELECTION
2 FOR MODEL 1B: CENTRE OF GENERATION
3 FOR MODEL 1C: POPULATION FORECASTS

Under Model #2/3 Reports:

a) ENTER - DESIRED ZONE # (1, 2, 3 --- , etc.)
- "99" to report all zones
- " 0" for no zone reports

b) DO YOU WANT A LIST OF OPTION DESCRIPTIONS (Y OR N)?

and

c) DO YOU WANT A COST SUMMARY BY ZONE (Y OR N)?

When all options are complete you are then given the option of "R"eturning to the main menu or "E"xiting SWAT Model by entering R or E.

Option 4 under the main menu allows the user to COPY A FILE. As a sub-option you may copy either "M"odel files or "R"eport files. Once chosen the appropriate file names are listed; the user enters one of the listed file names; and then the user is requested to enter a new file name. The data is copied to a file under the new name after the new file name has been entered by the user. After which the user again may "R"eturn to the main menu or "E"xit to APL or MS DOS.

Option 5 under the main menu allows the user to ERASE A FILE. A a sub-option the user may erase either "M"odel files or "R"eport files. Once chosen the appropriate file names are listed; the user enters one of the listed file names; and once the file has been deleted the user can again "R"eturn to the main menu or "E"xit to APL or MS DOS. It should be noted that once the user erases a "M"odel file the databases no longer exist and further model runs are not possible. Provided the "R"eport files are not erased they can be viewed or printed using option 3, "ACCESS EXISTING REPORTS".

Option 6 of the main menu allows the user to immediately "E"xit to APL or MS DOS as has been previously discussed.

SWAT Model Procedures

Option 1 of the main menu allows the user to enter the SWAT model procedures. The former discussion related to files and reports that had already been created through previous runs of the SWAT Model programs. The file management features were discussed first to give the user an appreciation of the basic files and reports that are created in SWAT Model and the various options available to help organize and maintain these files. Now the discussion will concentrate on the various procedures available to BUILD THE DATABASE.

Actually once the user chooses Option 1 to RUN SWATMODEL, the preliminary information requested by the program forms the foundation for BUILDing the DATABASE. The user enters a RUN NAME. This name must contain only characters (no numbers) and must be seven characters or less in length. This RUN NAME then is tied to all "M"odel files (that is, DATABASE files) and to a "R"eport component file which must be initially created to store reports (at the user's request) as well as other important

variables created throughout the SWAT Model run. This is the initial step in creating the DATABASE(s). At this point the user may use an EXISTING DATABASE (the user simply answers with a Y and presses RETURN to the question: Do you want to use existing databases? (Y or N)) or may enter a new database (by answering with a N and pressing RETURN to the above noted question). The computer program then sets up 48 components on the "R"eport file that will be used later in the various SWAT Model procedures. The example presented in Appendix II shows this as a consecutive listing of the numbers 1 through 48.

Subsequently the user is asked: Do you want a procedural description? (Y or N). If the user types "N" and presses the ENTER key, the program passes directly to the actual Model Procedures Menu. Otherwise, if the user enters "Y" a very general model description outline is initially presented as follows:

MODEL DESCRIPTION

BUILD DATABASE ---

MODEL 1 SITE SELECTION MODEL:

MODEL 1A - SITE OPTIONS SELECTION ANALYSIS
MODEL 1B - CENTRE OF GENERATION SITE LOCATION
MODEL 1C - ZONAL POPULATION FORECASTS

MODEL 2 COLLECTION SYSTEM MODEL

MODEL 3 RURAL COLLECTION MODEL

After the above outline is presented the user presses the ENTER key to proceed. At this point the user is presented with various optional procedural descriptions as follows:

```
ENTER   0 TO BUILD DATABASE
        1 FOR MODEL 1
       1A FOR MODEL 1A
       1B FOR MODEL 1B
       1C FOR MODEL 1C
        2 FOR MODEL 2
        3 FOR MODEL 3
        4 TO EXIT TO ACTUAL PROCEDURES
```

The user simply types the appropriate number or number/letter combinations and presses the ENTER key to get the desired procedural description. Each of the above noted procedural descriptions will be presented under the appropriate manual section headings.

Building the Database

The general procedural description that is presented on the screen (when requested by the user) is depicted in Figure 1.6 which describes in fairly general terms the database construction. As indicated in Figure 1.6 the user types "Y" and presses the ENTER key to continue the next description or types "N" and presses ENTER to continue to the Model Procedures Menu. Assuming the user does this the following menu will be presented to the user:

```
ENTER:  0 TO BUILD DATABASE
        1 TO USE MODEL 1
        2 TO USE MODEL 2/3
        3 TO EXIT
```

The user types "0" and presses ENTER to access the BUILD DATABASE procedure. Following this the user is presented with:

```
*****************************************************************************
*                                                                           *
*                          -  BUILD DATABASE -                              *
*                                                                           *
*    This component of the model prompts the user to insert as directed     *
*  model case-specific parameter data.  In some cases default values have   *
*  been supplied, which may be over-ridden.  Other linking variable data    *
*  are aquired output from a preceding model component, which provides the  *
*  information necessary as input to subsequent  model components.          *
*                                                                           *
*    Database is divided into four sub-files:                               *
*                                                                           *
*          1. ZONE, POPULATION AND HAULAGE COST input data                  *
*          2. LINK NETWORK CODE input data                                  *
*          3. POTENTIAL SITE LOCATIONS linking variable data, and           *
*          4. SITE ACCESS REQUIREMENTS linking variable data                *
*                                                                           *
*    The user may select the database of choice.                            *
*                                                                           *
*    For further details as to the nature, source and detailed procedures   *
*    of these databases, refer to Section 1.3.1 of the Users Guide.         *
*                                                                           *
*                              *** proceed to next description ? (Y or N) *** *
*****************************************************************************
```

Figure 1.6: Procedural Description - Build Database

WHICH DATABASE DO YOU WANT TO BUILD/EDIT?

ENTER: 1 FOR ZONE, POPOULATION AND HAULAGE COST
2 FOR LINK DATA
3 FOR POTENTIAL SITE LOCATIONS
4 FOR SITE ACCESS REQUIREMENTS
5 TO RETURN TO PREVIOUS MENU

By typing "1" and pressing ENTER the user is presented with the initial screen shown in Figure 1.7. After the user presses "CTRL R" (that is, press the "CTRL" key and the "R" key at the same time) they can then enter new data to override the default values shown on the screen.

ENTER NEW DATA TO OVERRIDE DEFAULT USING " ↓ " KEY

That is, type in the new entry (e.g., if you want to override the default value of 5 percent for average annual inflation rate with 6 percent, type 6) and press the " ↓ " key, which automatically sets the cursor at the next default value. Again, the user is referred to Appendix 2 for a sample run in which the BUILD DATABASE procedure was used.

The various data items and associated default values are shown in Figure 1.7. The AVERAGE ANNUAL INFLATION RATE is shown to be 5 percent and is based upon the recent (1986/87) trend in the inflation rate. Past history has shown this can vary considerably. Basically the user is responsible for determining an average inflation rate that seems most appropriate for the planning period being studied. The user should, however, take note that all base data in the model is based on 1986 data; the rationale for this was the fact that the latest Statistics Canada census data is 1986 and therefore will form the foundation for all population and population related data including

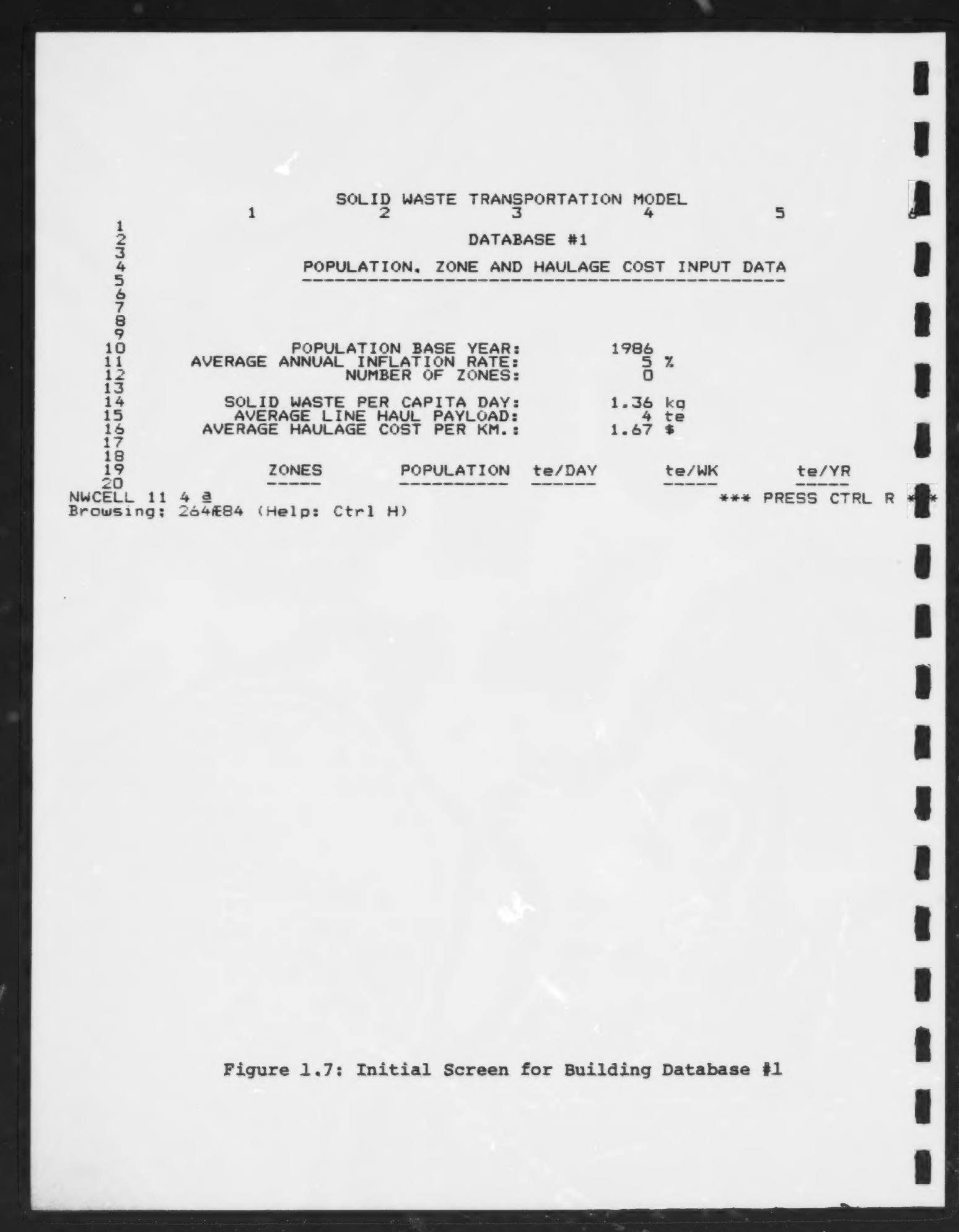

SOLID WASTE TRANSPORTATION MODEL
1 2 3 4 5
DATABASE #1
POPULATION, ZONE AND HAULAGE COST INPUT DATA
POPULATION BASE YEAR: 1986
AVERAGE ANNUAL INFLATION RATE: 5 %
NUMBER OF ZONES: 0
SOLID WASTE PER CAPITA DAY: 1.36 kg
AVERAGE LINE HAUL PAYLOAD: 4 te
AVERAGE HAULAGE COST PER KM.: 1.67 $
ZONES POPULATION te/DAY te/WK te/YR
NWCELL 11 4 a
*** PRESS CTRL R ***
Browsing: 264E84 (Help: Ctrl H)

Figure 1.7: Initial Screen for Building Database #1

costing data. The inflation rate therefore is actually used to growth all cost figures to the analysis year chosen (later) by the user.

The default value for NUMBER OF ZONES is 0; obviously the user is expected to enter the actual number of zones included in the study area. The study area can consist of:

1) Commission area only;
2) Commission area plus external rural area; or
3) External rural area only.

The three different situations depend upon the objective of the particular study being done. When the objective is to locate a central disposal site within a commission area and to determine the collection cost within this boundary, then all zones will be located within the Commission area. If it is decided that it would be better to locate a central disposal site to everybody's benefit (that is, those inside the Commission area plus the external rural residents) then both the Commission area plus the external rural area will be included. If various Commission areas, which surround an unserviced rural area, already have central disposal sites and the objective is to see which one would most meet the needs of the unserviced rural area, then the unserviced rural area will represent the study area. In the latter case the potential central disposal sites will be external to the study area. This is irrelevant to the SWAT Model computer program.

In any case, the study area is divided into various collection areas or zones by the user. Maps showing the study area, population centres, the road network and households or dwelling units will be required by the user. The basic criteria for

defining a zone is census tract data; that is, a village, town or city would each be a zone and each of the local service districts in the rural areas would be considered as a separate zone in general. The SWAT Model program is designed with an UPPER LIMIT OF 15 ZONES. The actual NUMBER OF ZONES is typed in to override 0 and the "↓" key is pressed.

The next data item in DATABASE #1 is SOLID WASTE PER CAPITA DAY which is the amount of domestic solid waste generated by each person in the study area per day. The default value of 1.36 kilograms was found to be an average number as determined from the various reports supplied by the Department of Municipal Affairs and Environment and various reference books used during the development of the SWAT Model. Again, it can be overrided by typing in another value or left as is and pressing the "↓" key.

AVERAGE LINE HAUL PAYLOAD was set at a default value of 4 tonnes based upon the average payload that could be expected in a transfer container or trailer user to make the final haul from the zone centroid (chosen by the user and generally assumed to be a mode on the primary road network located in the centre of the major population) to the potential central disposal sites. A more accurate estimate is not required at this point as this database will be used in the analysis procedure to define one best central disposal site out of a number of potential central disposal sites that may be considered. The option is provided, however, for the user to override the default value.

A similar rationale is used for the AVERAGE HAULAGE COST PER KM of $1.67. This is an average vehicle operating cost per kilometre based upon the information presented in the report Truck Operating Costs in Canada 1986, Transport Canada. Again, the user may, or may not, override the default value and the "↓" key is pressed.

The user then PRESSes CTRL R to PRODUCE ZONE #s automatically. At this point it is important to note that the zones are numbered consecutively from 1 to the total number of zones without skipping numbers. The user must use this convention. It is designed for automatic, consistent entry of data. After the zone numbers are presented on the screen the user again PRESSes CTRL R then the "↓" KEY TWICE. At this point the zone populations are typed in one at a time and the "↓" key is pressed after each entry. After the final zone population is entered the user PRESSes CTRL R, at which point the SWAT Model program automatically generates the remainder of DATABASE #1. That is, the tonnes of domestic solid waste generated in each zone per day (te/day), per week (te/wk), per year (te/yr) and subsequently the number of truck trips per week (TRIPS/WK) and the number of trips per year (TRIPS/YEAR).

THIS DATABASE IS COMPLETE - PRESS CTRL E TO PROCEED.

After the user presses CTR E, DATABASE #1 is automatically saved. Subsequently the user PRESSes CTRL X to CONTINUE. The user is asked: DO YOU WANT TO CREATE A REPORT FOR DATABASE #1? (Y or N). If the user types N and presses ENTER they will be returned to the Model Procedures Menu (see Figure 1.5 - SWAT MODEL USERS GUIDE FLOW CHART). If the user types "Y" and presses ENTER, a DATABASE #1 report will be generated and the user given the option of printing the report at that point or continuing (and printing the report at a later time). Assuming the user wants to access the report, they:

ENTER 1 TO VIEW THE REPORT
      2 TO PRINT THE REPORT
      3 TO CONTINUE TO THE NEXT PROCEDURE.

These options have been discussed previously. See Appendix II for a sample printout of DATABASE #1.

After accessing the report, the user is asked: DO YOU WANT TO CONTINUE EDITING DATABASES? (Y or N). Assuming the user wants to build the next database, they type "Y" and press ENTER. At this point the Build Database Menu reappears:

ENTER 1 FOR ZONE, POPULATION AND HAULAGE COST
2 FOR LINK DATA
3 FOR POTENTIAL SITE LOCATIONS
4 FOR SITE ACCESS REQUIREMENTS
5 TO RETURN TO PREVIOUS MENU

The user chooses 2 and presses ENTER to BUILD DATABASE #2, LINK DATA. Figure 1.8 shows the initial screen for BUILDING DATABASE #2. The user PRESSes CTRL R to ENTER THE ORIGIN and DESTINATION ZONES automatically. The origin and destination modes are assumed to be the zone centroids and simply have the same number as the zone number. The user PRESSes CTRL R again to ENTER THE LINK DISTANCES. The link distances are the road kilometres along the primary or major highway between zone centroids as identified by zone numbers. DIRECT LINKS are also identified. LINKS that connect two zone centroids without going through an intermediate zone centroid (or node) are considered DIRECT LINKS. This data is entered into DATABASE #2 in a question and answer form as follows:

ENTER THE LINK DISTANCES (KMS):
NODE: 1 TO NODE: 2

45 (45 is typed by the user and ENTER is pressed)

```
                    SOLID WASTE TRANSPORTATION MODEL
          14         15         16         17         18         19
  1
  2                        DATABASE #2
  3
  4                      LINK DATA FILE
  5                      --------------
  6
  7
  8
  9              CENTROID LINKS          DISTANCE  DIR. LINK ?
 10              -------- -----          --------  -----------
 11             ORIGIN        DEST         KMS     (1=Y 0=N)
 12             ------        ----         ---     ---------
 13
 14
 15
 16
 17
 18
 19
 20
NWCELL 9 19                                      *** PRESS CRTL R ***
Browsing; 264E84 (Help: Ctrl H)
```

Figure 1.8: Initial Screen for Building Database #2

IS THIS A DIRECT LINK? (Type 1 for Yes or 0 for No).

1 (1 is typed by the user and ENTER is pressed).

The computer program continues to the next unique origin-destination pair until the final entry is made. DATABASE #2 is displayed on the screen with the message:

THE LINK DATA IS COMPLETE - PRESS CTRL E TO PROCEED.

As before pressing CTRL E automatically saves the database. Subsequently the user PRESSes CTRL X to CONTINUE. Again, the user can create and print/view a report for DATABASE #2. With DATABASE #1 and #2 complete the user could run Model 1B - CENTRE OF GENERATION.

Assuming the user continues, however, to the Build Database Menu, the user types 3 and presses ENTER to BUILD DATABASE #3, POTENTIAL SITE LOCATIONS. Figure 1.9 shows the initial screen for building DATABASE #3. The user presses "CTRL R". See Appendix I to follow through the various stages of input. The following message appears on the second screen:

PRESS CTRL - E TO USE EXISTING DATA, OTHERWISE TYPE CTRL R

When entering data for the first time for all potential sites being considered, or when the user wishes to add potential sites, the " ↓ " key is pressed. The number of potential sites is typed and the ENTER key is pressed. Subsequently the user PRESSes "CTRL R" to which the program will respond with the following:

SOLID WASTE TRANSPORTATION MODEL
28 29 30 31 32 33
DATABASE #3
POTENTIAL SITE LOCATIONS INPUT DATA
OF POTENTIAL SITES:
SITE NODE NUMBER
SITE LINK LOCATION
DISTANCES
N Ci Cj FROM Ci FROM Cj
- -- -- -------- --------
*** PRESS CRTL R ***
Browsing; 264E84 (Help: Ctrl H)

Figure 1.9: Initial Screen for Building Database #3

FOR SITE NUMBER 1 ENTER SITE LINK IDENTIFICATION BY ORIGIN, DESTINATION (e.g., 1,2)

2,5 (the user types "2,5" and presses ENTER)

ENTER THE DISTANCE TO THE SITE FROM NODE 2 (KMS):

2.62 (the user types "2.62" and presses ENTER)

The program will continue in this manner until the location data is entered for all potential sites. As indicated in Figure 1.9 each potential central disposal site is identified by a NODE NUMBER, N. NOTE THAT SITE NODE NUMBERS ARE TO START AT 1 AND CONTINUE CONSECUTIVELY 2, 3, 4 AND SO ON to the final site, N. Gaps in the numbers are not allowed. This is done again by design to help automate data entry and to maintain strict control to prevent confusion that could arise with multiple identifying conventions. Each SITE NODE is considered to lie on a major highway link connecting two zone centroids, identified in Figure 1.9 as zone centroid, Ci; and Cj. Only the distance, in kilometres, is required for Ci; as the computer program automatically calculates the distance for Cj. It should be noted that this distance does not account for the distance off the major highway link into the actual disposal site (the access distance); the access distance is assumed to be approximately equal for all sites at this point and is therefore not required to determine which potential central disposal site would be the most cost-effective from a transportation point of view. Detailed access data is required in DATABASE #4 for the particular central disposal site that is chosen (in Model 1A). Once all site link location nodes and related distances are input the user presses CTRL E to automatically save DATABASE #3. Subsequently, the user PRESSes CTRL X to CONTINUE at which point the user can create and print/view a report for Database #3. Appendix II can be examined to see a sample report for DATABASE #3.

Assuming the user returns to the Build Database Menu, DATABASE #4 can be developed by typing 4 and pressing ENTER. The user is immediately entered into a question-answer format to enter the SITE ACCESS REQUIREMENTS.

Prior to considering the data entry procedure for DATABASE #4, the user should realize that in fact DATABASE #4 is broken into two parts. Part A is the construction and upgrading unit cost data that is applied over the length of the access road (access road, as previously identified, is the distance from the SITE NODE on the major highway network into the central disposal site which could include either an existing local road or a newly constructed access road or some combination of the two). Figure 1.10 shows the data included in DATABASE 4A - SITE ACCESS DATA UNIT COSTS OF ROAD INFRASTRUCTURE. The user has no direct interaction with this database, but is asked relevant questions to override the default data as follows:

WHAT IS THE ANALYSIS YEAR?

1987 (user types in this value and presses RETURN)

WHAT IS THE AVERAGE ANNUAL INFLATION RATES? (Return for 5%). (At this point the user may type an alternate value, e.g., 6; in either case the user presses RETURN).

WHAT IS THE INTEREST RATE? (Return for 10%). (Again, the user may type an alternate value, e.g., 12; in either case the user presses RETURN).

WHAT IS THE AMORTIZATION PERIOD? (Return for 10 years). (As before, the user may type an alternate value, e.g., 15; in either case the user presses RETURN).

ARE THE ABOVE VALUES OKAY? (Y or N) (The user types Y and presses RETURN if the values are correct, otherwise they type N and press RETURN).

If the user enters "N" to the above question the program loops back to the first question: WHAT IS THE ANALYSIS YEAR? When the user enters "Y" the program automatically inflates the 1986 unit costs of road infrastructure values shown in Figure 1.10. The original unit cost values were determined in consultation with the staff at the New Brunswick Department of Transportation. They represent overall average unit costs to be used for planning purposes and are not representative of a detailed design cost estimate for a particular road construction project.

Figure 1.11 shows a sample SITE ACCESS REQUIREMENTS DATABASE. Again the user does not interact directly with this database, but rather answers individual questions for <u>each</u> potential central disposal SITE being considered. The computer program automatically addresses each SITE in turn. Following are the questions asked of the user:

This information is entered by the user for each of the potential SITES. For example, the computer program would continue to the next site as follows:

THIS SITE REFERENCE NUMBER 2
WHAT IS THE TOTAL LENGTH OF THE ACCESS ROAD (KMS)?
and so on for all sites (as identified in DATABASE #3). After the data entry for the final SITE is complete the user PRESSes CTRL E to PROCEED at which point the user may create and print/view a report for DATABASE #4 (using the same procedures discussed previously for the other databases). After this the user is asked: DO YOU WANT TO CONTINUE EDITING DATABASES? (Y or N). If the user enters "Y" they are returned to the Build Database Menu; if they enter "N, they are returned to the Model Procedures Menu.

DATABASE 4A

SITE ACCESS DATA

UNIT COSTS OF ROAD INFRASTRUCTURE

ANALYSIS YEAR:	1987
COST BASE YEAR:	1986
AVERAGE ANNUAL INFLATION RATE:	5 %
INTEREST RATE:	10 %
AMMORTIZATION PERIOD:	10 yrs

ROAD SURFACE:	GRAVEL	CHIP SEAL	PAVEMENT
NEW CONSTR. ACCESS BASE & SURFACE ($/km):	60000	90000	1.40000E+05
RECONSTR. OF EXISTING RD. BASE & SUR. ($/km):	40000	60000	70000
EXISTING ROAD RESURF./UPGRD. ($/km):	12000	10000	27000
SHOULDER UPGRD. ($/km):	650	1000	1100
DITCHING ($/km):	2000	2000	2000
STRUCTURES ($):	25000	25000	25000
CULVERTS ($):	2000	2000	2000
HIGHWAY INTERCHNGE ($):	3.00000E+06	3.00000E+06	3.00000E+06
AT-GRADE INTERSCT. ($):	1.20000E+05	1.20000E+05	1.20000E+05
ANNUAL MAINT. ($/km):	16000	16000	16000

Figure 1.10: Site Access Data Unit Costs of Road Infrastructure

DATABASE 4B

SITE ACCESS REQUIREMENTS INPUT DATA

SITE REF. NUMBERS	ACCESS ROAD LENGTH (KMS)			ROAD STANDARD (0=na,1=gravel, 2=chip seal,3=pavement)		
N	NEW	RECONST.	RESURFAC	NEW	RECONST.	RESURFAC
-	---	---	---	---	---	---

CONSTRUCT/RECONSTRUCT BASE & SURFACE		RESURFACE /UPGRADE	SHOULDER UPGRADE	DITCHING WORK	STRUCTURES (number)	
NEW	EXISTING	EXISTING	EXISTING	EXISTING	NEW	EXISTIN
---	---	---	---	---	---	---

OR

HIGHWAY INTERCHANGE	AT-GRADE INTERSECT.	ANNUAL SITE MAINTENANCE	
EXISTING	EXISTING	NEW	EXISTING
---	---	---	---

Figure 1.11: Site Access Requirements Database

At this point Model 1A - SITE OPTIONS SELECTION ANALYSIS would normally be run in order to identify the best central disposal site (which will be used later in Model 2/3 - COLLECTION SYSTEM MODEL). IT SHOULD ALSO BE NOTED THAT THE CENTRAL DISPOSAL SITE, IDENTIFIED THROUGH MODEL 1B - CENTRE OF GENERATION SITE LOCATION, SHOULD ALSO BE ENTERED INTO DATABASE #3 (even if it is the only site being considered since Model 2/3 accesses DATABASE #3 for central disposal site location information). This is not to imply that Model 1B must be run and a centre of generation site determined; it simply means that, if such a site has been determined, it must be entered into DATABASE #3 in order to be used later in the SWAT Model.

1.3.2 Model 1 - Site Selection Model

Model 1 is the SITE SELECTION MODEL used to determine the best central disposal site out of a number of potential sites as defined by the user (in DATABASE #3). The procedure is accessed by choosing option 1 TO RUN SWATMODEL from the SWAT Model Main Menu. After the user enters the preliminary information (RUN NAME, optionally loads an existing database), the user can optionally get a general description of Model 1 by choosing option 1 from the Procedural Description Menu, and then continue on to the actual Model Procedures Menu:

```
ENTER  0 TO BUILD DATABASE
       1 TO USE MODEL 1
       2 TO USE MODEL 2/3
       3 TO EXIT.
```

The user types "1" and presses ENTER to access the Model 1 procedures. The user is again referred to Figure 1.5 SWAT MODEL USERS GUIDE FLOW CHART to trace the aforementioned steps to access the Model 1 procedures.

If the user has chosen option 1 from the procedural Description Menu the general description shown in Figure 1.12(a) would be presented on the screen. As indicated in Figure 1.12(a), Model 1 consists of three submodels:

1A: SITE OPTIONS SELECTION ANALYSIS;
1B: CENTRE OF GENERATION SITE LOCATION; and
1C: ZONAL POPULATION FORECASTS.

Each of these models 1A, 1B and 1C are described in Figures 1.12(b), 1.12(c) and 1.12(d), respectively. Again, these procedural descriptions are accessed by the user through the Procedural Description Menu (see the Users Guide Flow Chart in Figure 1.5).

1.3.2.1 Model 1A - Site Options Selection Analysis

Model 1A, the SITE OPTIONS SELECTION ANALYSIS, is briefly described in Figure 1.12(b). The following sections define the model entry procedures, data input requirements and the resulting report generated by the model.

Model Entry

The user enters the Model 1A procedures by: (Refer to the USERS GUIDE FLOW CHART in Figure 1.5)

1. First entering the SWAT Model Main Menu;

2. Choosing option 1 TO RUN SWATMODEL;

FIGURE 1.12(a): SITE SELECTION MODEL PROCEDURAL DESCRIPTION

- SITE SELECTION MODEL -

Model 1 is comprised of three interconnecting submodels:

1A: SITE OPTIONS SELECTION ANALYSIS
1B: CENTRE OF GENERATION SITE LOCATION, and
1C: ZONAL POPULATION FORECASTS

These models draw input from the Database files and permit the user case-specific input data entries and/or choice of analytical options. Models 1B and 1C provide input to Model 1A. Model 1B provides the analyst the site location(s) at the centre of solid waste generated which minimizes transportation. Model 1C allows the analyst to test the results of Model 1B and 1A subject to changes in population growth and distribution. Model 1A reports the solid waste disposal site location which produces the least transportation infrastructural and operating costs

For further information refer to Section 1.3.2 of the User Guide.

*** proceed to next description ? (Y or N)***

FIGURE 1.12(b): SITE OPTIONS SELECTION ANALYSIS PROCEDURAL DESCRIPTION

```
**********************************************************************
*                                                                    *
*                  - SITE OPTIONS SELECTION ANALYSIS -               *
*                                                                    *
*    Model 1A selects the solid waste disposal site location from the input *
*  set of site location options based upon minimization of the costs of site *
*  access infrastructural requirements and delivery from throughout the *
*  given commission area.                                            *
*                                                                    *
*    The potential disposal site locations based upon environmental impact *
*  analyses and/or Model 1B - the Center of Solid Waste Generation Site *
*  Location(s) - are input onto the coded highway network by the analyst *
*  for each site location.  The ammortized transport infrastructure and *
*  delivery trip distances costs are calculated for each site location and *
*  the least-cost site selected.                                     *
*                                                                    *
*    For further details refer to Section 1.3.2.1 of the User Guide. *
*                                                                    *
*                                                                    *
*                                                                    *
*                                                                    *
*                                                                    *
*                    *** proceed to next description ? (Y or N) *** *
**********************************************************************
```

FIGURE 1.12(c): CENTRE OF GENERATION SITE LOCATION
PROCEDURAL DESCRIPTION

- CENTRE OF GENERATION SITE LOCATION -

Model 1B indicates solid waste disposal site location(s) on the coded highway network, at which solid waste delivery distances from the entire Commission population area are minimized.

The first step of the program indicates the zonal centroid of the link network at which the tonne-kilometers of solid waste delivery are minimized. The next program step identifies the link along which the site can best be located. Appraisal of the environmental acceptability of the link for solid waste disposal site preceeds the programs final selection of the best location(s). These site location(s) are used as input to Model 1A - the Site Options Selection Analysis.

For further details, refer to Section 1.3.2.2 of the User Guide.

*** proceed to next description ? (Y or N) ***

FIGURE 1.12(d):
ZONAL POPULATION FORECASTS PROCEDURAL DESCRIPTION

```
*************************************************************************
*                                                                       *
*                        - ZONAL POPULATION FORECASTS -                 *
*                                                                       *
*     Model 1C allows the analyst to rerun Models 1A and 1B to test the *
*  sensitivity of population growth to the solid waste disposal site selection *
*  process.  The analyst is offered several choices of forecasting      *
*  techniques:                                                          *
*                                                                       *
*                * overall uniformly applied growth rate.               *
*                * zonal trend growth projections.                      *
*                * individual zonal growth rates, and                   *
*                * urban vs. rural split zonal growth rates.            *
*                                                                       *
*     For further details, refer to Section 1.3.2.3 of the User Guide.  *
*                                                                       *
*     NOTE: Zonal Population Forecasts may also be used later in MODEL 2/3 - *
*           the COLLECTION SYSTEM MODEL.                                *
*                                                                       *
*                                                                       *
*                                                                       *
*                                                                       *
*                                  *** proceed to next description ? (Y or N) *** *
*************************************************************************
```

3. Completing Preliminary data requirements - RUN NAME and LOADING AN EXISTING DATABASE (if the user intends to BUILD the DATABASE during the same model run the BUILD DATABASE procedure would have to be run first rather than LOADING AN EXISTING DATABASE);

4. Proceeding to the Model Procedures Menu; and

5. Choosing option "1" TO USE MODEL 1 at which point the sub-option menu of Model 1 would appear on the screen.

From the sub-option menu:

WHICH SUB-OPTION OF MODEL 1 DO YOU WANT?

ENTER: A FOR SITE SELECTION
B FOR CENTRE OF GENERATION
C FOR POPULATION FORECAST
D TO RETURN TO PREVIOUS MENU

the user types "A" and presses ENTER. At this point Model 1A immediately begins running without any further input required of the user.

Running Model 1A

Model 1A uses DATABASE #1, DATABASE #2, DATABASE #3 AND DATABASE #4, all of which have been previously defined in section 1.3.1 of the Users Manual. The program therefore runs without any additional input. The user is presented with a summary result on the computer screen. A typical summary from Model 1A is shown in Figure 1.13. At this point the user is given the option of creating and printing/viewing the results of Model 1A.

FIGURE 1.13: SAMPLE SUMMARY RESULT FOR MODEL 1A
(AS SEEN ON THE SCREEN)

SITE #:	ACCESS ROAD COST	DELIVERY COST	TRANSPORT COST
1	58378	54726.6	1.13105E+05
2	72206.9	73154	1.45361E+05
3	1.46084E+05	1.14629E+05	2.60713E+05

*** HIT ANY KEY TO PROCEED ***

(See section 1.3.1 for details with respect to creating and printing/viewing reports). Following are the steps for printing Model 1A reports:

```
DO YOU WANT TO CREATE A REPORT FOR MODEL 1A?  (Y OR N)
Y


A REPORT NAMED SAMPLEB HAS BEEN CREATED



DO YOU WANT TO USE THE REPORT AT THIS TIME? (Y OR N)
Y
```

Figure 1.14 shows an example of a Model 1A report. The SITES are identified by their site reference numbers (see section 1.3.1). The sites are also located by link (that is, between zone centroids, Ci and Cj, on the major highway network a noted distance in kilometrs from Ci and from Cj).

In addition the distance of access road length in kilometres requiring NEW construction, the length requiring RECONSTRuction and the length that needs to be RESURFACEd is presented as well. This in essence indicates the extent of highway and road infrastructure improvements that are required for each potential central disposal site. Below the site location information the Model 1A results are presented (and are exactly the same as the results that are presented to the user on the screen, see Figure 1.13). The annualized access road infrastructure improvement costs are shown for each potential site (they include all costs related to the infrastructure improvements identified in

FIGURE 1.14: EXAMPLE OF A MODEL 1A REPORT

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE0 DATE: 1986/1/20 13:08

MODEL 1A: SITE OPTIONS SELECTION MODEL REPORT

SITE #:	SITE LINKS CI	CJ	DISTANCE FROM CI	CJ	ACCESS ROAD LENGTH (KMS) NEW	RECONSTR.	RESURFACE
1	2	5	2.8	1.2	2	0	0
2	3	5	12.6	11.9	0	0	0
3	1	3	14.5	17.5	0	3	0
4	2	5	2.62	2.38	2	0	0

SITE #:	ANNUALIZED ACCESS ROAD COST	ANNUAL DELIVERY COST	TOTAL SITE TRANSPORT COST
1	58378	54726.6	1.13105E+05
2	72206.9	73154	1.45361E+05
3	1.46084E+05	1.14629E+05	2.60[illegible]7E+05
4	58378	54229.8	1.12608E+05

DATABASE #4, see section 1.3.1). The annual delivery cost for the whole study area are also presented. The delivery costs are basically the total line haul cost of hauling the domestic solid waste from each zone centroid to the central disposal site (including the empty return haul). The annualized access road cost and annual delivery cost are combined to provide an estimated total site transport cost per year for each potential site.

The total annual site transport cost indicates to the user which of the potential sites is the best from a transportation cost point of view only. In Figure 1.14, SITE #4 is the best site from a transportation cost minimization perspective. Other environmental and social factors may be more relevant at this point in the analysis); as a result, the user is left with the responsibility of making the final choice. (In terms of evaluating the environmental and social considerations the user is referred to section 1.2.3 - Qualitative Evaluation of Other Factors).

Note that the SITE chosen at this point is input manually at the start of the Collection System Model 2/3. Details regarding Model 2/3 are presented in section 1.3.3 of the Users Manual.

1.3.2.2 Model 1B - Centre of Generation Site Location

Model 1B, the CENTRE OF GENERATION SITE LOCATION, is briefly described in Figure 1.12(c). The following paragraphs and examples define the model entry procedures, data input requirements and the resulting report generated by the model.

The first note that should be made by the user is that the Model 1B procedure should be run prior to running Model 1A when a centre of generation site is determined. By its very nature,

the central disposal site located by determining the centre of generation of the domestic solid waste minimizes the total annual line haul costs associated with delivering the solid waste from each zone centroid to the central disposal site. Therefore, no other site, as determined by some other means (e.g., environmental and social impact assessment), will provide for a lower annual line haul cost. If a site located in the centre of generation is not to be included in any particular study, then Model 1B need not be run at all and only Model 1A would be run.

Model Entry

As previously discussed, the user initially enters the SWAT Model and proceeds to the sub-option menu of Model 1 in order to access the Model 1B procedures. At this point the user is presented with the following and responds accordingly:

```
WHICH SUB-OPTION OF MODEL 1 DO YOU WANT?
ENTER:  A FOR SITE SELECTION
        B FOR CENTRE OF GENERATION
        C TO RETURN TO PREVIOUS MENU
```

The user simply types "B" and presses ENTER.

Running Model 1B

Model 1B uses only DATABASE #1 and DATABASE #2. Therefore, the program requires no further input from the user. The results from the model run are printed on the screen. These results are similar to the report shown in Figure 1.15.

At this point the user has the option of creating and printing/ viewing a report of Model 1B results (see procedural description in section 1.3.1). The basic steps are:

```
DO YOU WANT TO CREATE A REPORT FOR MODEL #1B?  (Y OR N)
Y


A REPORT NAMED SAMPLEC HAS BEEN CREATED




DO YOU WANT TO USE THE REPORT AT THIS TIME? (Y OR N)
Y


WHAT DO YOU WANT TO DO?
ENTER: 1 TO VIEW THE REPORT
       2 TO PRINT THE REPORT
       3 TO CONTINUE TO THE NEXT PROCEDURE
:
     2
```

Figure 1.15 shows a sample report for Model 1B.

As previously discussed Model 1B basically determines the centre of generation of the domestic solid waste. To do this, initially each zone centroid is assumed to be a potential central solid waste disposal site. Figure 1.15 shows the results of this first stage of Model 1B in terms of a ZONE CENTROID TONNE-KM SUNS REPORT. The LINK TONNE-KMS shown for each zone centroid represents the total line haul tonne-kilometres that would result if that zone were the central

FIGURE 1.15: EXAMPLE OF A MODEL 1B REPORT

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE0 DATE: 1988/1/20 13:09

MODEL 1B: SITE OPTIONS SELECTION MODEL REPORT

ZONE CENTROID TONNE-KM SUMS REPORT

ZONES	POPULATION	LINK TONNE-KMS
1	1036	1.01516E+05
2	2886	41389.2
3	546	73959.9
4	752	53262.5
5	1023	38128

MINIMUM SELECTED LINK TONNE-KM CENTROID: 5
BEST LINK FOR SITE: 5 2

SITE LOCATION AREA
DISTANCE FROM CENTROID 5 = 2.38248 km
DISTANCE FROM CENTROID 2 = 2.61751 km

disposal site and the solid waste from all other zones were hauled to that site (zone centroid). The zone with the minimum link tonne-kilometres is the centre of generation site. Because a central disposal site would not be located directly in the middle of a population centre, the centre of generation site is finally located by the model along the direct link to an adjacent zone with the minimum link tonne-kilometres (not necessarily the zone with second lowest tonne-kilometres because it has to be an adjacent zone with a direct link to the zone with the minimum tonne-kilometres. The final section of the report in Figure 1.15 therefore identifies the zone centroid resulting in the minimum link tonne-kilometres, the best link along which the centre of generation site is located (identified by zone centroid numbers) and the distance along the major highway link to the centre of generation site to each centroid.

The user should note that the centre of generation site should be entered into DATABASE #3, potential site locations, and DATABASE #4, site access requirements in order to generate an estimate of the line haul and infrastructure costs using Model 1A and if the collection system options are to be evaluated for the centre of generation site using Model 2/3, Collection System Model (described in section 1.3.3).

1.3.2.3 Model 1C - Zonal Population Forecasts

Model 1C, a sub-option of Model 1 for developing ZONAL POPULATION FORECASTS, is briefly described in Figure 1.12(d). The following paragraphs and examples define the model entry procedures, data input requirements and the resulting report generated by the model.

This model allows the user to test the impact of future population growth in the study area upon the results of running:

Model 1A - SITE SELECTION,
Model 1B - CENTRE OF GENERATION, OR
Model 2/3 - COLLECTION SYSTEM MODEL.

Model 1C is used to forecast the population and redefine the DATABASE #1 population to reflect the increase (or potential decrease) in zonal population for the particular year in which the user is interested. Obviously if the impact of population growth is to be accounted for, Model 1C must be run prior to running any of the aforementioned models. Model 1C requires that DATABASE #1, the zone and population database, be built first.

Model Entry

Regardless of the forecasting technique used when running Model 1C (see Figure 1.12(d)) the model entry procedures are the same. The user chooses 1 from the SWAT MODEL Main Menu and continues to the Model Procedures Menu, at which point the user:

ENTER: 0 TO BUILD DATABASE
1 TO USE MODEL 1
2 TO USE MODEL 2/3
3 TO EXIT

1
enters Model 1 by typing 1 and pressing ENTER; then

WHICH SUB-OPTION OF MODEL 1 DO YOU WANT?

ENTER: A FOR SITE SELECTION
B FOR CENTRE OF GENERATION
C FOR POPULATION FORECAST
D TO RETURN TO PREVIOUS MENU

C

enters Model 1C by Typing C and pressing ENTER.

Once the user enters Model 1C they are presented with a choice of forecasting techniques as shown in Figure 1-16. The user types in the option number for the desired POPULATION FORECAST PROCEDURE and presses the ENTER key. Subsequently the user presses "CTRL R" to enter the particular forecasting procedure. Details of each forecasting technique are presented below. After each forecasting procedure has been completed, the user may produce and print/view reports of the results. The basic procedure is the same as previously presented for other model procedures:

```
DO YOU WANT TO CREATE A REPORT FOR THIS POPULATION PROJECTION?
(Y OR N)
Y

DO YOU WANT TO USE THE REPORT AT THIS TIME? (Y OR N)
Y

WHAT DO YOU WANT TO DO?

ENTER:  1 TO VIEW THE REPORT
        2 TO PRINT THE REPORT
        3 TO CONTINUE TO THE NEXT PROCEDURE

2
```

Each forecasting technique is discussed below.

Option 1 - Provincial Overall Growth Rate

Once the user has chosen option 1 (see Figure 1.16) from the forecast procedures, they are presented with a screen as shown in Figure 1.17(a). At this point the user types in the OVERALL

FIGURE 1.16

SCREEN DEPICTING CHOICE OF POPULATION FORECAST PROCEDURES

```
                    SOLID WASTE TRANSPORTATION MODEL
          69         70         71         72         73         74
    45
    46
    47
    48                    MODEL 1C - POPULATION FORECASTS
    49
    50
    51          POPULATION FORECAST PROCEDURES:
    52
    53             1.      PROVINCIAL OVERALL GROWTH RATE
    54             2.      PROVINCIAL URBAN/RURAL GROWTH RATES
    55             3.      LINEAR PROJECTION OF HISTORIC DATA
    56             4.      ZONAL OVERALL GROWTH RATE
    57             5.      ZONAL URBAN/RURAL GROWTH RATES
    58
    59
    60
    61
    62
    63
    64                                                              0
sLa                  *** ENTER DESIRED PROCEDURE NUMBER THEN PRESS CTRL R ***
Browsing: 264E84 (Help: Ctrl H)
```

FIGURE 1.17(a)

DATA ENTRY SCREEN FOR PROVINCIAL OVERALL GROWTH RATE

```
                    SOLID WASTE TRANSPORTATION MODEL
          74          75          76          77          78          79
10                                      OVERALL GROWTH RATE(%)
11                                                          ----------
12
13                              FUTURE PROJECTED POPULATION
14        1987        1988        1991        1996        2001        2006
15        ----        ----        ----        ----        ----        ----
16
17
18
19
20
21
22
23
24
25
26
27
28
29
sda                     *** ENTER GROWTH RATE, RETURN, THEN PRESS CTRL R ***
Browsing: 264E84 (Help: Ctrl H)
```

GROWTH RATE in percent and presses ENTER; after which the user presses "CTRL R". The user must determine this growth rate external to the SWAT Model program. This growth rate can be determined from provincial statistics provided by the Province of New Brunswick or from Statistics Canada publications. The Provincial Overall Growth Rate is considered to be the most aggregate form of forecasting which makes no differentiation in growth rates within zones or among zones. A sample screen presenting forecasts using the PROVINCIAL OVERALL GROWTH RATE is presented in Figure 1.17(b). The base year for all projections is taken to be 1986 since this is the latest year for relatively comprehensive census data from Statistics Canada. Projections are then presented for the years 1987, 1988, 1991, 1996, 2001 and 2006 so that the user can choose a future year representative of a short term, medium term and long term planning period. The same information is presented in report form in Figure 1.18. The final step is for the user to choose the desired forecast year to be used in other model procedures:

WHICH FORECAST YEAR DO YOU WANT TO USE?

ENTER: 1986
1987
1988
1991
2001
OR
2006

(NOTE - Entering 1986 will recalculate database #1 values to original year if the population has already been changed to a forecast year by running this procedure.)

2001 (user enters choice and presses ENTER)

FIGURE 1.17(b)

SCREEN PRESENTING FORECASTS USING
PROVINCIAL OVERALL GROWTH RATE

SOLID WASTE TRANSPORTATION MODEL

74	75	76	77	78	79
		FUTURE PROJECTED POPULATION			
1987	1988	1991	1996	2001	2006
----	----	----	----	----	----
1047	1059	1094	1156	1221	1289
2918	2950	3048	3220	3401	3592
552	558	577	609	643	680
760	769	794	839	886	936
1034	1046	1081	1141	1205	1273

*** PRESS CTRL E TO PROCEED ***

Browsing: 264Æ84 (Help: Ctrl H)

FIGURE 1.18

REPORT GENERATED USING PROVINCIAL OVERALL GROWTH RATE

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE0 DATE: 1988/1/20 13:15

MODEL #1C: POPULATION FORECAST OPTIONS REPORT

PROVINCIAL OVERALL GROWTH RATE (%): 1.1

ZONES	PRESENT 1986	FUTURE PROJECTED POPULATION 1987	1988	1991	1996	2001	2006
1	1036	1047	1059	1094	1156	1221	1289
2	2896	2918	2950	3048	3220	3401	3592
3	546	552	558	577	609	643	680
4	752	760	769	794	839	886	936
5	1023	1034	1046	1081	1141	1205	1273

The computer takes a few minutes to redefine database #1 at this point and then SWAT Model returns the user to the Model Procedures Menu (see Figure 1.5, Users Guide Flow Chart).

Option 2 - Provincial Urban/Rural Growth Rates

Figure 1.19(a) shows the data entry screen presented to the user when they choose option 2 (see Figure 1.16) from the forecasting procedures. In this case the user must enter a growth rate for urban areas, in percent, and a separate rate for rural areas within the study area as a whole. In addition, the urban/rural split must be entered, that is the percentage of urban population in the study area as a whole. The overall growth rate is automaticaly calculated by the computer program from the above information. Again, this is a fairly aggregate forecasting procedure with only a differentiation between urban and rural areas. Again, the user must use Provincial or Statistics Canada data to determine the growth rate and urban/rural split in population. Figure 1.20 shows the final report resulting from this forecasting procedure. Basically the same information as presented in Figures 1.19(a) and 1.19(b) is shown in Figure 1.20.

After the user chooses a forecast year,

WHICH FORECAST YEAR DO YOU WANT TO USE?

ENTER: 1986
1987
1988
1991
1996
2003
OR
2006

FIGURE 1.19(a)

DATA ENTRY SCREEN FOR PROVINCIAL URBAN/RURAL GROWTH RATES

```
                              SOLID WASTE TRANSPORTATION MODEL
            74          75          76          77          78          79
 3 OPTIONAL:    PROVINCIAL POPULATION GROWTH RATE -     URBAN(%)
 4                                                                 ----------
 5                                                       RURAL(%)
 6                                                                 ----------
 7                                                URBAN/RURAL SPLIT(%)
 8                                                                 ----------
 9                                                    >>>>>OR<<<<<
10                                                OVERALL GROWTH RATE(%)
11                                                                 ----------
12
13                                FUTURE PROJECTED POPULATION
14        1987        1988        1991        1996        2001        2006
15        ----        ----        ----        ----        ----        ----
16
17
18
19
20
21
22
a                *** ENTER PROVINCIAL URBAN GROWTH RATE (%) THEN TYPE  TWICE ***
Browsing: 264Æ84 (Help: Ctrl H)
```

FIGURE 1.19(b)

SCREEN PRESENTING FORECASTS USING PROVINCIAL URBAN/RURAL GROWTH RATES

SOLID WASTE TRANSPORTATION MODEL

	74	75	76	77	78	79
12						
13			FUTURE PROJECTED POPULATION			
14	1987	1988	1991	1996	2001	2006
15	----	----	----	----	----	----
16	1046	1056	1085	1137	1192	1249
17	2913	2940	3024	3168	3320	3478
18	551	556	572	599	628	658
19	759	766	788	826	865	906
20	1033	1042	1072	1123	1177	1233
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

& *** PRESS CTRL E TO PROCEED ***

Browsing: 26484 (Help: Ctrl H)

FIGURE 1.20

REPORT GENERATED USING PROVINCIAL URBAN/RURAL GROWTH RATES

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE0 DATE: 1988/1/20 13:28

MODEL #10:

PROVINCIAL

URBAN(%)	0.9 %
RURAL(%)	1.15 %
URBAN/RURAL SPLIT(%)	85 %
>>>>>OR<<<<<	
OVERALL GROWTH RATE(%)	0.9375 %

ZONES	PRESENT 1986	FUTURE PROJECTED POPULATION 1987	1988	1991	1996	2001	2006
1	1036	1046	1056	1085	1137	1192	1249
2	2886	2913	2940	3024	3168	3320	3478
3	546	551	556	572	599	628	658
4	752	759	766	788	826	865	906
5	1023	1033	1042	1072	1123	1177	1233

(NOTE: Entering 1986 will recalculate database #1 values to original year if the population has already been changed to a forecast year by running this procedure.)

:

2001

the model returns them to the Model's Procedure Menu.

Option 3 - Linear Projection of Historic Data

Figure 1.21(a) shows the data entry screen presented to the user when they choose option 3 (see Figure 1.16) from the forecasting procedures. This data entry form is different from those previously presented in that the user is asked to enter actual historic population data for each zone. In this disaggregate form the user must gather census data for each zone within the study area for the census years 1971, 1976, and 1981. The base year data entered in DATABASE #1 is also shown on the screen. The user, after pressing "CTRL R" is requested to enter data as follows:

ENTER THE HISTORIC POPULATION FOR ZONE #1 FOR 1971, 1976, 1981
(eg: 300, 570, 1500)
:
821,900,930
ENTER THE HISTORIC POPULATION FOR ZONE #2 FOR 1971, 1976, 1981
(eg: 300, 570, 1500)
:
2502,2646,2781
ENTER THE HISTORIC POPULATION FOR ZONE #3 FOR 1971, 1976, 1981
(eg: 300, 570, 1500)
:
553,575,621
ENTER THE HISTORIC POPULATION FOR ZONE #4 FOR 1971, 1976, 1981
(eg: 300, 570, 1500)
:

FIGURE 1.21(a)

DATA ENTRY SCREEN FOR LINEAR PROJECTION OF HISTORIC DATA

```
                        SOLID WASTE TRANSPORTATION MODEL
        68          69          70          71          72          73
 12
 13                                          HISTORIC POP.                   PRESENT
 14                 ZONES        1971        1976        1981            1986
 15                 -----        ----        ----        ----            ----
 16                     1                                                   1036
 17                     2                                                   2886
 18                     3                                                    546
 19                     4                                                    752
 20                     5                                                   1023
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
sMa                                  *** PRESS CTRL R TO ENTER HISTORIC DATA ***
Browsing: 264E84 (Help: Ctrl H)
```

657,703,748
ENTER THE HISTORIC POPULATION FOR ZONE #5 FOR 1971, 1976, 1981 (eg: 300, 570, 1500)
:
811,897,960

After the data entry is complete, the user is presented with the results as shown in Figure 1.21(b). Again, the user can produce and print a report presenting the predicted population for each zone. A sample report is presented in Figure 1.22. Again, the report is similar to the results presented to the user on the computer screen.

After viewing the results and/or getting a report for the projections the user again chooses a forecast year to be used in other model procedures (see the previous procedure above). The model returns the user to the Model Procedures Menu at this point.

Option 4 - Zonal Overall Growth Rate

Figure 1.23(a) shows the data entry screen presented to the user when they choose option 4 (see Figure 1.16) from the forecasting procedures. This again is a disaggregate form of projecting the future population. That is, the user enters a specific, overall average growth rate for each zone included in the study area. The actual growth rate is determined externally from the SWAT Model from Statistics Canada census data of estimates made by the Province of New Brunswick. The user should note that the headings: urban, rural and urban/rural split (see Figure 1.23(a) are not used with this particular forecasting procedure and therefore the user is not directed by the computer program to this particular area of the spreadsheet. These columns of information are used in the following forecasting technique (5. ZONAL URBAN/RURAL GROWTH RATES).

FIGURE 1.21(b)

SCREEN PRESENTING FORECASTS USING A LINEAR PROJECTION OF HISTORIC DATA

SOLID WASTE TRANSPORTATION MODEL

74	75	76	77	78	79
		FUTURE PROJECTED POPULATION			
1987	1988	1991	1996	2001	2006
----	----	----	----	----	----
1038	1051	1091	1156	1222	1287
2923	2948	3026	3154	3283	3412
578	579	580	583	585	588
771	778	798	831	864	897
1042	1054	1098	1167	1237	1307

*** PRESS CTRL E TO PROCEED ***

Browsing: 26484 (Help: Ctrl H)

FIGURE 1.22

REPORT GENERATED USING A LINEAR PROJECTION OF HISTORIC DATA

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLEQ DATE: 1988/1/20 14:02

MODEL #1C:

LINEAR PROJ

	HISTORIC POP.			PRESENT
ZONES	1971	1976	1981	1986
1	821	900	930	1036
2	2502	2646	2781	2886
3	553	575	621	546
4	657	703	748	752
5	811	897	960	1023

FUTURE PROJECTED POPULATION					
1987	1988	1991	1996	2001	2006
1037	1050	1091	1158	1226	1293
2923	2948	3026	3154	3283	3412
578	579	580	583	585	588
771	778	798	831	864	897
1042	1056	1098	1167	1237	1307

FIGURE 1.23(a)

DATA ENTRY SCREEN FOR ZONAL OVERALL GROWTH RATE

```
                    SOLID WASTE TRANSPORTATION MODEL
          78          79          80          81          82          83
                                ZONAL GROWTH RATES
   12
   13                                                 URBAN/RURAL
   14               ZONES    URBAN        RURAL        SPLIT     OVERALL AVG
   15               -----    -----        -----        -----     -----------
   16                   1
   17                   2
   18                   3
   19                   4
   20                   5
   21
   22
   23
   24
   25
   26
   27
   28
   29
   30
   31
s0a                                *** PRESS CTRL R THEN TYPE  FOUR TIMES ***
Browsing: 264f84 (Help: Ctrl H)
```

After the data has been entered the user is presented with the results in spreadsheet form on the computer screen as shown in Figure 1.23(b). Again, future projected populations are depicted for each zone in the study area. If the user produces a report (shown in Figure 1.24), it shows the same information as is presented in Figures 1.23(a) and 1.23(b).

After viewing the results and/or generating a report for the zonal population projections, the user chooses a forecast year to be used in other model procedures (Model 1A, 1B or Model 2/3).

Option 5 - Zonal Urban/Rural Growth Rates

Figure 1.25(a) shows the data entry screen presented to the user when they choose option 5 (see Figure 1.16) from the forecasting procedures. The procedure presented here using ZONAL URBAN/ RURAL GROWTH RATES is very similar to the last forecasting technique. With this technique the growth rates are disaggregated to the zonal level but also differentiate even further between areas of urban development and those of rural development. Urban development refers to areas with population concentration equivalent to cities, towns or villages; even though a local service district may not have the population base to warrant village status there may be a concentration of population within adjacent subdivisions that would be classed as urban development. The user is responsible for determining the urban/ rural split and the associated growth rates. Again, they can use Provincial and Statistics Canada information to develop the required urban and rural growth rates for each zone.

In this particular procedure the user is prompted for input by zone number for each zone similar to the following example:

FIGURE 1.23(b)

SCREEN PRESENTING FORECASTS USING ZONAL OVERALL GROWTH RATE

```
                                SOLID WASTE TRANSPORTATION MODEL
        74          75              76              77              78              79

12
13                                  FUTURE PROJECTED POPULATION
14      1987        1988            1991            1996            2001            2006
15      ----        ----            ----            ----            ----            ----
16      1047        1056            1082            1161            1221            1289
17      2913        2936            3056            3220            3401            3487
18       551         559             577             609             629             649
19       761         769             794             827             856             945
20      1034        1046            1073            1116            1214            1273
21
22
23
24
25
26
27
28
29
30
31                                                  *** PRESS CTRL E TO PROCEED **
```

Browsing: 26484 (Help: Ctrl H)

FIGURE 1.24

REPORT GENERATED USING ZONAL OVERALL GROWTH RATE

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLEQ DATE: 1988/1/20 14:31

MODEL #1C:

ZONAL OVERA

OVERALL AVG

1.1
0.95
0.87
1.15
1.1

ZONES	PRESENT 1986	FUTURE PROJECTED POPULATION 1987	1988	1991	1996	2001	2006
1	1036	1047	1056	1082	1161	1221	1289
2	2886	2913	2936	3056	3220	3401	3487
3	546	551	559	577	609	629	649
4	752	761	769	794	827	856	945
5	1023	1034	1046	1073	1116	1214	1273

FIGURE 1.25(a)

DATA ENTRY SCREEN FOR ZONAL URBAN/RURAL GROWTH RATES

```
                    SOLID WASTE TRANSPORTATION MODEL
        77          78          79          80          81          82
                                                ZONAL GROWTH RATES
 12                                                          URBAN/RURAL
 13
 14                                  ZONES   URBAN       RURAL       SPLIT
 15                                  -----   -----       -----       -----
 16                                    1
 17                                    2
 18                                    3
 19                                    4
 20                                    5
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
sT@                    *** PRESS CTRL R TO ENTER THE ZONAL GROWTH RATES ***
Browsing: 264£84 (Help: Ctrl H)
```

```
ENTER THE URBAN AND RURAL GROWTH RATES (%) FOR ZONE #1 (eg:
0.9,2):
:
       .7,1.35
ENTER THE URBAN PORTION OF THE ZONE POPULATION (%)? (eg: 75)
:
       40
ENTER THE URBAN AND RURAL GROWTH RATES (%) FOR ZONE #2 (eg:
0.9,2):
:
       .7,1.35
ENTER THE URBAN PORTION OF THE ZONE POPULATION (%)? (eg: 75)
:

       100
ENTER THE URBAN AND RURAL GROWTH RATES (%) FOR ZONE #3 (eg:
0.9,2):
:
       .7,1.35
ENTER THE URBAN PORTION OF THE ZONE POPULATION (%)? (eg: 75)
:
       5
ENTER THE URBAN AND RURAL GROWTH RATES (%) FOR ZONE #4 (eg:
0.9,2):
:
       .7,1.35
ENTER THE URBAN PORTION OF THE ZONE POPULATION (%)? (eg: 75)
:
       5
ENTER THE URBAN AND RURAL GROWTH RATES (%) FOR ZONE #5 (eg:
0.9,2):
:
       .6,1.4
ENTER THE URBAN PORTION OF THE ZONE POPULATION (%)? (eg: 75)
:
       30
```

After the input is complete the user is presented with the results on the computer screen as shown in Figure 1.25(b). Note that the computer program has automatically calculated the overall average zonal growth rate and from this has generated the future projected population for each zone for the years 1987, 1988, 1991, 1996, 2001 and 2006. The same results are also shown in a report generated by the user as depicted in Figure 1.26. The user is in the final step requested to enter a forecast year:

DO YOU WANT TO USE A FORECAST YEAR FOR MODEL 1A AND/OR MODEL 1B?
(Y OR N)
Y

WHICH FORECAST YEAR DO YOU WANT TO USE?

ENTER 1986
1987
1988
1991
1996
2001
OR
2006

(NOTE: Entering 1986 will recalculate database #1 values to original year if the population has already been changed to a forecast year by running this procedure.)

:
1986

At this point, the user is returned to the Model Procedures Menu and can continue onto Model 1A or 1B and from these to Model 2/3.

FIGURE 1.25(b)

SCREEN PRESENTING FORECASTS USING
ZONAL URBAN/RURAL GROWTH RATES

SOLID WASTE TRANSPORTATION MODEL

	74	75	76	77	78	79
12						
13			FUTURE PROJECTED POPULATION			
14	1987	1988	1991	1996	2001	2006
15	----	----	----	----	----	----
16	1047	1051	1106	1181	1232	1287
17	2906	2963	3081	3239	3396	3318
18	553	560	578	609	606	709
19	762	770	794	806	915	977
20	1035	1045	1059	1166	1245	1288
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

*** PRESS CTRL E TO PROCEED ***

Browsing: 26484 (Help: Ctrl H)

FIGURE 1.26

REPORT GENERATED USING ZONAL URBAN/RURAL GROWTH RATES

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE0 DATE: 1989/1/20 14:43

MODEL #10:

ZONAL URBAN

ZONAL GROWTH RATES

URBAN	RURAL	URBAN/RURAL SPLIT	OVERALL AVG
0.7	1.35	40	1.09
0.7	1.35	100	0.7
0.7	1.35	5	1.3175
0.7	1.35	5	1.3175
0.6	1.4	30	1.16

	PRESENT	FUTURE PROJECTED POPULATION					
ZONES	1986	1987	1988	1991	1996	2001	2006
1	1036	1047	1051	1106	1181	1232	1287
2	2886	2906	2963	3081	3239	3396	3318
3	546	553	560	578	609	606	709
4	752	762	770	794	806	915	977
5	1023	1035	1045	1059	1166	1245	1288

1.3.3 Model 2/3 - Collection System Model

As presented in the methodology in Section 1.2 of the report, the SITE SELECTION process represents only Phase 1 of the SWAT Model (see Figure 1.1). At this point the user has only identified the best central disposal site to serve the study area. Phase 2 is the use of a local collection system model that will identify the total system; that is, the best collection and site system. Model 2/3, the COLLECTION SYSTEM MODEL, provides the user with the means to achieve the best collection site system.

The general Model 2/3 description can be listed on the computer screen by entering the SWAT Model and proceeding to the Procedural Description Menu (see Figure 1.5 - SWAT MODEL USERS GUIDE FLOW CHART):

```
ENTER  0  TO BUILD DATABASE
       1  FOR MODEL 1
       1A FOR MODEL 1A
       1B FOR MODEL 1B
       1C FOR MODEL 1C
       2  FOR MODEL 2
       3  FOR MODEL 3
       4  TO EXIT TO ACTUAL PROCEDURES.
```

The user types "2" and presses ENTER to list the general description presented in Figure 1.27. The user should note that there is also a procedural description for Model 3, a Rural Collection System Model. It is also presented in Figure 1.27. Models 2 and 3 are, in fact, really one collection system model identified as Model 2/3 throughout the various procedures available in SWAT Model. The distinction is made here to bring to the attention of the user the fact that the same model (Model 2) can be used to find the best collection and site system for

- MODEL # 2 -
- COLLECTION SYSTEM MODEL -

Model #2 compares the per annum costs collection and delivery systems of solid waste to the selected site for each population zone of a Commission area. The analyst is required to expand the link road network within and to the zone boundaries according to sub-population areas within the zone. Households per link and link distances are also measured for input.

The model computes link population and household densities and prorates them for the zone. These data are used to calculate collection rates per collection system and time the collection cycle. The model determines the per annum costs of the alternate collection and delivery systems to the solid waste disposal site based on operating times and distances and equipment costs. Alternate systems include equipment variations of:

1. curbside collection delivered direct to the disposal site, to a container site and hauled to the disposal site, as well as to a transfer station for haulage to the disposal site; and

*** press ENTER to continue ***

- COLLECTION SYSTEM MODEL (CONTINUED) -

2. user delivery direct to the disposal site, user delivery to a container site and hauled on to the disposal site, user delivery to a container site and hauled to the disposal site, user delivery to a transfer station and hauled on to the disposal site.

*** proceed to next description ? (Y or N) ***

- MODEL # 3 -
- RURAL COLLECTION SYSTEM MODEL -

Rural areas outside of the designated Commission areas may be appraised for alternate collection and delivery of Solid Waste systems using Model 2. Each non-Commission rural area is set up as a zone with a zone centriod and the centroid to site distance assigned to an adjacent Commission disposal site. It is then analysed as if it were another zone of the Commission for the alternate collection and delivery system costs.

*** type "ENTER" to proceed ***

FIGURE 1.27

COLLECTION SYSTEM MODEL DESCRIPTION

rural areas external to a Commission Area (s) as well as for within a Commission Area. The difference is merely is how the user compiles the data (as detailed in the following Section 1.3.3.2 Data Input).

1.3.3.1 Model Entry

Model 2/3, Collection System Model, can be accessed by the user by proceeding to the Model Procedures Manual (see Figure 1.5):

ENTER: 0 TO BUILD DATABASE
1 TO USE MODEL 1
2 TO USE MODEL 2/3
3 TO EXIT

The user types "2" and presses ENTER to start the Model 2/3 procedures.

The user should note that prior to running Model 2/3, the Model 1A - SITE OPTIONS SELECTION ANALYSIS should have been run. This does not imply that Model 1A needs to be run during the same computer run, but does imply that, if not, an existing model database, in which the results from Model 1A were saved, must be loaded prior to making the Model 2/3 computer run in order to be able to identify the best central disposal site.

1.3.3.2 Data Input

Model 2/3, Collection System Model, uses data from each of the databases:

- DATABASE #1 - ZONE, POPULATION;
- DATABASE #2 - LINK NETWORK CODE;
- DATABASE #3 - SITE LOCATION DATA; AND
- DATABASE #4 - SITE ACCESS REQUIREMENTS.

These databases have been described previously in Section 1.3.1 BUILDING DATABASES/DATABASE MANAGEMENT/REPORTING.

In addition to the above information, the user is asked to submit further information regarding the total length of road (in kilometres) and the number of households by zonal link. That is, the major highway network within a zone is divided into a number of links based upon centroid modes, zone boundaries and major intersections. Each link is numbered from 1 consecutively up to and including the final link in that particular zone (link numbers start again at 1 in each zone). A link will have associated with it various local roads and/or streets (that may, or may not, intersect directly with the particular link). The basic criteria is that the surrounding local road network and development density (households per kilometre) should be relatively uniform; the household density per kilometre, that is associated with each link (number), effectively determines the garbage collection rate for any collection system options which include curbside/roadside collection of domestic waste. This requires that the user measure the total road/street kilometreage associated with each link (this includes the length of the particular link plus all the connecting/interconnecting road network assigned to that particular link). This can be done with sufficient accuracy using 1:50 000 scale topographic mapping available from the Department of Energy, Mines & Resources. As well, the user must identify and count all the households along the link and the connecting/interconnecting road network assigned to that particular link). Again this can be done using the above noted mapping, or, if desired, by field survey of the area or some combination of the two. Household information should be taken from the same mapping as was the link distances data, or at least from a source of same year. This is to ensure an accurate number of households:link distance ratio. It is on this ratio that link/zone population and household densities are based. Ideally, this data would be found for 1986.

To help clarify this data input various figures have been prepared. Figure 1.28(a) depicts a hypothetical Commission Area which has been broken into five zones (which, as previously indicated, represent municipalities, local service districts or areas of major census divisions). The five zones are connected by a major or primary highway network (identified in DATABASE #2 as centroid links and denoted as such by using centroid nodes which were equivalent to zone number). Centroid links are not to be confused with zonal links as identified below.

Figure 1.28(b) identifies the zonal links for zone number 2 (see Figure 1.28(a)). The zonal links break at zone boundaries, the zone centroid and include major highway sections other than centroid links (examples include zonal link numbers 4, 5 and 6 which are never included as part of a centroid link). The assumption is that the household density in the area of each link is relatively uniform. The development density related to zonal link number 4 is considered, in this example, to be sufficiently different from that related to zonal link number 5 to warrant the identification of two separate zonal links.

Figure 1.28(c) shows link number 3 and the related road/street network associated with this particular zonal link. In this case the user is responsible for measuring the total road/street kilometreage related to the zonal link including the length of the link itself and for counting all the households along this road/street network.

A typical zonal link dataset that would be prepared by the user is as follows:

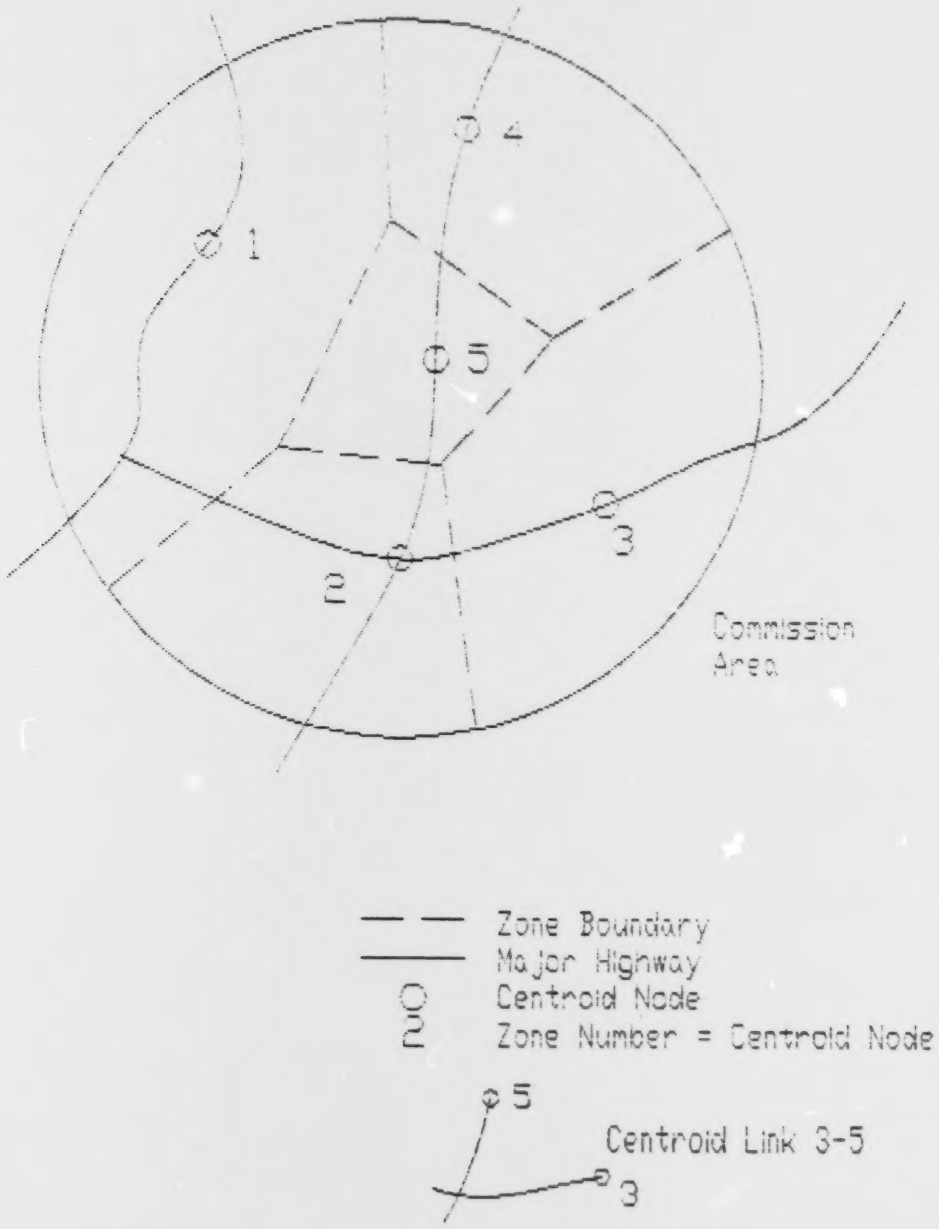


FIGURE 1.28(a)

HYPOTHETICAL COMMISSION AREA AND ZONAL DIVISIONS

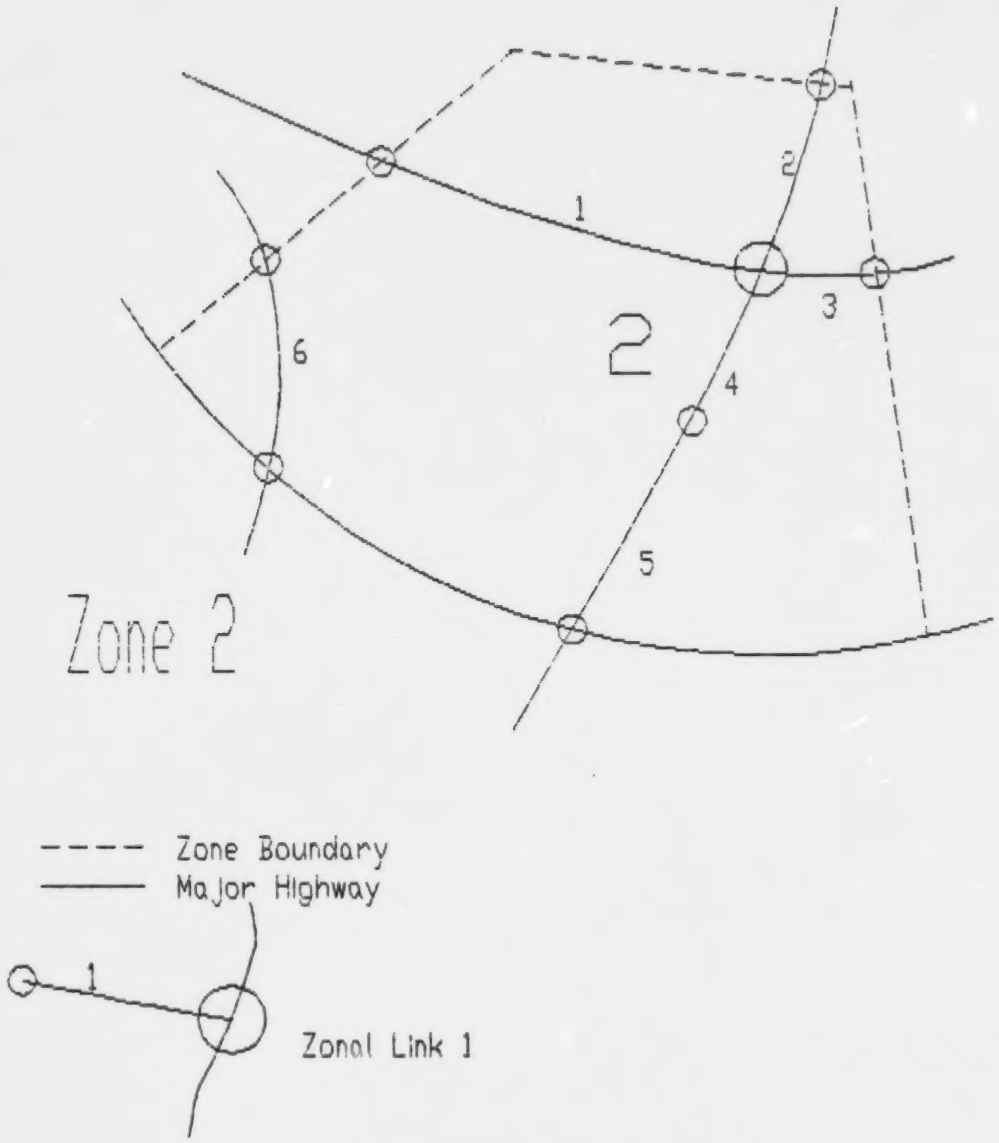
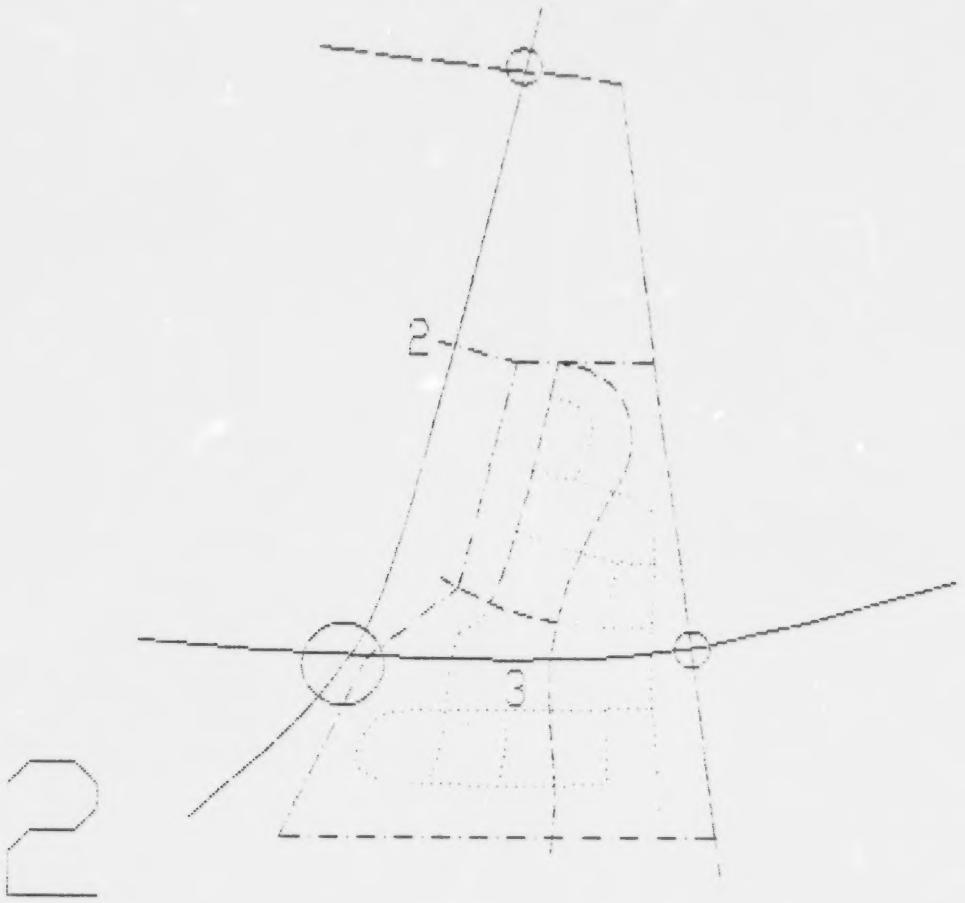


FIGURE 1.28 (b)

MAGNIFIED VIEW OF ZONE 2 SHOWING ZONAL LINKS



Zone Boundary
Major Highway
Link Boundary
Minor Road/Street

FIGURE 1.28(c)

MAGNIFIED VIEW OF ZONAL LINK 3 and RELATED ROAD/STREET NETWORK

Sample Zonal Link Dataset

Zone	Link	Road/Street Kilometreage	Household Density (HH/km)
1	1	17	120
1	2	12	60
1	3	8	100
1	4	14	90
2	1	10	200
2	2	30	195
2	3	18	260
2	4	22	175
2	5	11	175

... and so on for each link in each zone within the study area.

The above data is the type of information initially requested of the user after the Model 2/3 procedures have been requested by the users. The first request is for the desired central disposal site number to be used for the Model 2/3, at which point the user is provided with the various site numbers as has been previously entered by the user in DATABASE #3. After which the user then enters the zonal link data. Following is a typical run of Model 2/3:

```
WHICH SITE DO YOU WANT TO CONSIDER FOR THIS RUN? (ENTER THE SITE
# 1)
:
      1
FOR ZONE 1 ENTER THE NUMBER OF LINKS:
:
      4
FOR LINK 1 ENTER THE TOTAL ROAD DISTANCE, TOTAL HOUSEHOLDS:
:
      17,120
```

```
FOR LINK 2 ENTER THE TOTAL ROAD DISTANCE, TOTAL HOUSEHOLDS:
:
      12,60
FOR LINK 3 ENTER THE TOTAL ROAD DISTANCE, TOTAL HOUSEHOLDS:
:
      8,100
FOR LINK 4 ENTER THE TOTAL ROAD DISTANCE, TOTAL HOUSEHOLDS:
:
      14,90
FOR ZONE 2 ENTER THE NUMBER OF LINKS:
:
      5
FOR LINK 1 ENTER THE TOTAL ROAD DISTANCE, TOTAL HOUSEHOLDS:
:
      10,200
FOR LINK 2 ENTER THE TOTAL ROAD DISTANCE, TOTAL HOUSEHOLDS:
:
      30,195
FOR LINK 3 ENTER THE TOTAL ROAD DISTANCE, TOTAL HOUSEHOLDS:
:
```

and so on for each zone and each zonal link. The final data requested deals with transfer stations:

```
DO YOU WANT TO CONSIDER A TRANSFER STATION FOR ANY OF THE ZONES?
(Y OR NO):
N
```

In this example no transfer station was used. However, in a large study area a transfer station may be considered. The user simply enters the zones (zone numbers) that are to use the transfer station. This particular decision is left to the discretion of the user. Probably a transfer station would be considered where two zones are particularly high generators of domestic waste and yet the central disposal site is located much closer to one zone than the other.

The above is the typical data input required for running Model 2/3 for a study area confined to a Commission Area (described as Model 2 in Figure 1.27). From the computer program operation point of view, this is no different than running Model 2/3 for an external rural noncommission area that may be surrounded by various Commission Areas. The only distinction that is required is from the user's point of view. For within Commission Area studies all potential central disposal sites are within the boundaries of the study area. For those study areas restricted to noncommission rural areas, the potential disposal sites are external to the study area and are predetermined potential sites (therefore, Model 1B, Centre of Generation Site, need not be run). The surrounding Commission Areas (in which potential central disposal sites are located) are included in the analysis as zones for the study area (being the noncommission rural area), but these Commission Area zones are considered to have no population and therefore generate no domestic waste. The centroid for these Commission Areas is considered to be the central disposal site. All the previously defined databases are required including:

- DATABASE #1 - ZONAL, POPULATION DATA;
- DATABASE #2 - CENTROID LINK DISTANCE DATA;
- DATABASE #3 - SITE LOCATION DATA; AND
- DATABASE #4 - SITE ACCESS REQUIREMENTS.

DATABASE #4 will generally have to be completed with zero access road construction and upgrading requirements (under certain circumstances Commission Areas may feel upgrading will be warranted if external rural areas are to use their particular central disposal site). For other databases the Commission Areas represent artificial zones with zero population, but with a defined centroid link distance to all other zones. Model 1B can be run to identify the best central disposal site to be used

as input to Model 2/3. In Model 2/3 each artificial zone (Commission Area is considered to be one zone with zero road/ street distance and zero households. Model 2/3, Collection Systems Model, is run as previously described. Figure 1.29 depicts the basic database structure for a rural noncommission study area. The zones are numbered consecutively from 1 through to the last zone including the artificial zones. Similarly, the potential central disposal sites are numbered consecutively from 1 through to the final site being considered. Centroid link distances are measured, in kilometres, along the major highways between zone centroids, including the centroids for the artificial zones. In other words, the rural noncommission area and associated commission areas are all considered part of the study area.

1.3.3.3 Internal Database

Once the user has entered Model 2/3 and input the required data the model is ready to produce annual costs per zone for each of 20 solid waste collection system options. Figure 1.30 indicates the components of each collection system option (Note: a report of these collection options is available to the user as desired; see Model Procedures section following.) These collection system options were developed through meetings with the Client, various reports and background documentation, interviews with collection system operators in New Brunswick and the Maritimes, and through interviews with manufacturers of solid waste collection equipment.

The first five collection system options involve curbside collection and user delivery direct to the disposal site. The next ten options (6 to 15) involve collection and haulage to

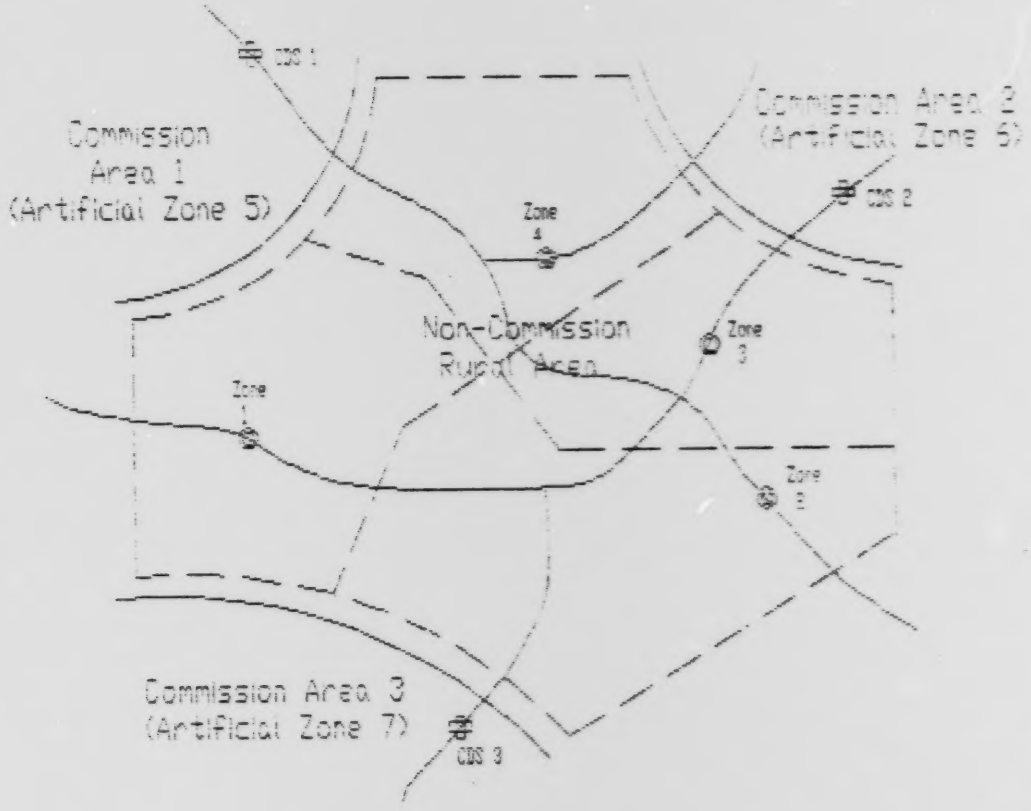


FIGURE 1.29

DATABASE STRUCTURE FOR A RURAL NON-COMMISSION AREA

FIGURE 1.30

MODEL 2/3: SOLID WASTE COLLECTION SYSTEM OPTIONS

OPTION 1: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - direct haulage to disposal site.

OPTION 2: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - direct haulage to disposal site.

OPTION 3: Curbside collection by 25 cy Side-Load Compaction vehicle with 8.50 te capacity - direct haulage to disposal site.

OPTION 4: Curbside collection by 25 cy Rear-Load Compaction vehicle with 9.07 te capacity - direct haulage to disposal site.

OPTION 5: Individual household - direct haulage to disposal site.

OPTION 6: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - haulage to container site with 3 20 cy Non Compaction Roll-On/Roll-Off Containers with 2.00 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 20 cy size container.

OPTION 7: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - haulage to container site with 3 40 cy Non Compaction Roll-On/Roll-Off Containers with 3.99 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 8: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - haulage to container site with 3 40 cy Non-Compaction Roll-On/Roll-Off Containers with 3.99 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 9: Curbside collection by 20 cy Non-Compaction vehicle with 2.00 te capacity - haulage to container site with 3 40 cy Compaction Roll-On/Roll-Off Containers with 12.70 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 10: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - haulage to container site with 3 40 cy Compaction Roll-On/Roll-Off Containers with 12.70 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 11: Individual household - haulage to container site with 3 8 cy Non -Compaction Dump Containers with a site capacity of 2.40 te - haulage to disposal site by 25 cy Rear-Loading Compaction Container Dumper with a 10.20 te capacity.

OPTION 12: Individual household - haulage to container site with 5 8 cy Non -Compaction Dump Containers with a site capacity of 4.0 te - haulage to disposal site by 40 cy Front-Loading Compaction Container Dumper with a 10.00 te capacity.

OPTION 13: Individual household - haulage to container site with 3 20 cy Non-Compaction Roll-On/Roll-Off Containers with 2.00 te capacity -haulage to disposal site by tilt-frame truck capable handling up to 20 cy size container.

OPTION 14: Individual household - haulage to container site with 3 40 cy Non-Compaction Roll-On/Roll-Off Containers with 2.49 te capacity -haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 15: Individual household - haulage to container site with 3 40 cy Compaction Roll-On/Roll-Off Containers with 2.00 te capacity - haulage to disposal site by tilt-frame truck capable handling up to 40 cy size container.

OPTION 16: Curbside collection by 20 cy Non Compaction vehicle with 2.00 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 17: Curbside collection by 25 cy Non-Compaction vehicle with 2.49 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 18: Curbside collection by 25 cy Side-Load Compaction vehicle with 8.50 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 19: Curbside collection by 25 cy Rear-Load Compaction vehicle with 9.07 te capacity - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.01 te.

OPTION 20: Individual household - haulage to transfer station - haulage to disposal site by 75 cy tractor trailer van with a capacity of 17.05 te.

local containers and movement of the containers on to the disposal site. The last five options (16 to 20) involve use of a fixed open push pit transfer station for transferral to a tractor-trailer van for delivery to the disposal site.

Operating costs per system option were determined using the Transport Canada: Operating Costs of Trucking in Canada - 1986 technique. It should be noted that all equipment and site capital costs are annualized for inclusion in the total system operating costs.

Operating costs are given in 1986 dollars on a per hour basis for application to curbside collection operations and loading and unloading times at the container sites and/or the disposal site. Operating costs are also given on a per kilometre basis for application to line haul delivery to the container sites and/or disposal site. Individual household direct haulage operating costs to a container site, transfer station or disposal site are estimated at $0.25 per kilometre, assuming an average midsize vehicle.

The relative operating costs per annum of the system options will depend upon the following complex of cost variables:

- system equipment capital costs
- system vehicle operating costs
- system manpower requirements
- zonal population served
- zonal population density
- collection rates and time
- delivery distances
- loading and unloading times
- vehicle, container and transfer station capacities
- vehicle, container and transfer station capacity utilization.

The most appropriate collection system for a particular zone is the least cost system. The model computes the annual costs per option by summing the appropriate combination system component costs:

1. collection component costs:
a) collection costs
b) line haul costs
c) unloading costs.

2. user delivery costs.

3. transfer component costs:
a) container line haul costs
b) container load/unloading costs
c) transfer station line haul costs
d) transfer station load/unloading costs.

Table 1.1 illustrates the total costs per week and per annum calculated by the model for a zone for each of the 20 collection system options. Zeros are indicated under each system option where the cost item is not applicable. This table is reported for each zone with the least cost system option indicated.

Tables 1.2 and 1.3 indicate the unit costs and equipment specifications appropriate to the collection and transfer components, respectively.

1.3.3.4 Model 2/3 Results

As with the previous model procedures Model 2/3 generates various optional reports for the user. Once the model procedure runs the first questions asked of the user are:

SOLID WASTE TRANSPORTATION MODEL

MODEL 2: COLLECTION MODEL

SYSTEM COST REPORT

COSTS	OPTIONS																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CURBSIDE COLLECTION TO DISPOSAL SITE:																				
Collection Cost:	70	78	84	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	99	100	71	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	59	15	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIRECT USER DELIVERY TO DISPOSAL SITE:																				
User Delivery Cost:	0	0	0	0	871	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONTAINER SITE TO DISPOSAL SITE:																				
Collection Cost:	0	0	0	0	0	86	86	93	86	93	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	0	0	0	0	0	29	29	32	29	32	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	0	0	0	0	0	59	59	15	59	15	0	0	0	0	0	0	0	0	0	0
User Delivery Cost:	0	0	0	0	0	0	0	0	0	0	258	258	258	258	258	0	0	0	0	0
Container Line Haul Cost:	0	0	0	0	0	71	150	150	315	315	61	65	71	150	315	0	0	0	0	0
Container Load/Unload Cost:	0	0	0	0	0	19	40	40	84	84	36	35	19	40	84	0	0	0	0	0
TRANSFER STATION TO DISPOSAL SITE:																				
Collection Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	78	84	111	0
Line Haul Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	137	120	78	77	0
Unloading Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59	15	11	11	0
User Delivery Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	379
Transfer Station Line Haul Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7
Transfer Station Load/Unload Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	42	42	42	42
TOTAL SYSTEM COST (WEEKLY):	228	201	166	191	871	264	364	330	573	539	355	357	347	448	657	315	263	224	249	428
TOTAL SYSTEM COST (ANNUALLY):	11831	10446	8636	9945	45279	13707	18912	17172	29787	28046	18443	18586	18065	23271	34145	16405	13651	11626	12929	22279

TABLE 1.1

TABLE 1.2

SOLID WASTE COLLECTION COMPONENT UNIT COSTS ($1986)

Collection Component Equipment Specifications	Capital Cost ($)	Collection Component Unit Operating Costs	
		$/km	$/hr
20 c.y. noncompaction vehicle w/2.0 to capacity (one-man operation)	23,100	1.43	45.86
20 c.y. noncompaction vehicle w/2.0 to capacity (two-man operation)	23,100	1.75	56.22
25 c.y. noncompaction vehicle w/2.5 to capacity (one-man operation)	37,200	1.57	50.52
25 c.y. noncompaction vehicle w/2.5 to capacity (two-man operation)	37,200	1.89	60.86
25 c.y. side-load compaction vehicle w/8.5 to capacity (one man-operation)	102,100	2.05	65.86
25 c.y. rear-load compaction vehicle w/9.1 to capacity (one-man operation)	97,700	2.02	64.86
25 c.y. rear-load compaction vehicle w/9.1 to capacity (two-man operation)	97,700	2.33	75.13
Individual household average mid-size vehicle (operator cost excluded)	15,500	0.25	n.a.

TABLE 1.3

SOLID WASTE TRANSFER COMPONENT UNIT COSTS ($1986)

Transfer Component Equipment Specifications (each includes a site operator)	Capital Cost ($)	Transfer Component Unit Operating Costs $/km	$/hr
3-20 c.y. containers	13,275		
site land and construction	45,000		
tilt frame truck	90,000		
total	148,000	2.05	65.84
3-40 c.y. containers	14,610		
site land and construction	45,000		
tilt frame truck	100,000		
total	159,610	2.17	69.71
3-40 c.y. compaction containers	19,800		
2 c.y. compactor	12,500		
site land and construction	45,000		
tilt frame truck	100,000		
total	177,300	2.28	73.41
3-8 c.y. containers	3,135		
site land and construction	19,500		
25 c.y. rear load compaction container dumper vehicles	90,000		
total	112,635	1.76	56.58
5-8 c.y. containers	5,225		
site land and construction	19,500		
40 c.y. front load compaction container dumper vehicle	115,000		
total	139,725	1.88	60.57
fixed 200 t.p.d. open pit compaction transfer station	121,500		
site land and construction	70,000		
75 c.y. tractor-trailer van	166,500		
total	358,000	2.25	126.80

```
WHICH ZONES DO YOU WISH TO REPORT?

ENTER  DESIRED ZONE #s 1,2,3 ... etc.
       "99" to report all zones
       " 0" for no zone reports
:
       99
DO YOU WANT A LIST OF OPTION DESCRIPTIONS? (Y OR N)
Y
```

The user may not desire any zonal reports in which case they type "0" and press ENTER. Otherwise they type in the appropriate zone number or "99" for all zones and press ENTER. The user may also choose at this point to get a list of the collection sytem option descriptions. There are 20 collection system options are previously described. Therefore, they are referenced by option number on all reports to make the reports concise and manageable.

The collection system options report is exactly as has been previously presented in Figure 1.30 (see Section 1.3.3.3). A sample system cost report for zones is presented in Figure 1.31. This particular report may be produced for each zone in the study area. The various system costs (as defined in Section 1.3.3.3) are presented for each of the 20 collection system options as identified by option number (1 to 20 inclusive). This system cost summary is also broken down into the categories of: curbside collection, direct user delivery, container site and transfer station component costs. Where particular systems costs do not apply zeros have been entered. The TOTAL SYSTEM COST for the particular zone is presented in the bottom row on a weekly and an annual basis. The final summary information is presented in the lower left corner of the report in which the zonal population is presented for the particular planning year

SOLID WASTE TRANSPORTATION MODEL

DATE: 1988/1/18 10:37

COMMISSION: SAMPLEB ZONE # 1 SITE # 1

MODEL 2: COLLECTION MODEL

SYSTEM COST REPORT

COSTS	OPTIONS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CURBSIDE COLLECTION TO DISPOSAL SITE:																				
Collection Cost:	209	230	250	328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	746	682	356	351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	144	31	18	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIRECT USER DELIVERY TO DISPOSAL SITE:																				
User Delivery Cost:	0	0	0	0	8038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONTAINER SITE TO DISPOSAL SITE:																				
Collection Cost:	0	0	0	0	0	209	209	230	209	230	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	0	0	0	0	0	72	72	66	72	66	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	0	0	0	0	0	144	144	31	144	31	0	0	0	0	0	0	0	0	0	0
User Delivery Cost:	0	0	0	0	0	0	0	0	0	0	777	777	777	777	777	0	0	0	0	0
Container Line Haul Cost:	0	0	0	0	0	178	189	189	396	396	153	163	178	189	396	0	0	0	0	0
Container Load/Unload Cost:	0	0	0	0	0	16	16	16	35	35	30	29	16	16	35	0	0	0	0	0
TRANSFER STATION TO DISPOSAL SITE:																				
Collection Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
User Delivery Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transfer Station Line Haul Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transfer Station Load/Unload Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL SYSTEM COST (WEEKLY):	1099	943	625	698	8038	619	631	532	857	758	960	969	971	982	1208	0	0	0	0	0
TOTAL SYSTEM COST (ANNUALLY):	57152	49060	32491	36279	417979	32201	32791	27679	44538	39426	49905	50387	50476	51066	62813	0	0	0	0	0

ZONE POPULATION: 1239
POPULATION YEAR: 2001
ANALYSIS YEAR: 1987
TRANSFER STATION ZONE # 0
OTHER ZONES USING TRANSFER STATION

LOWEST COST OPTION # 8 COST: $ 27678.5905

FIGURE 1.31

with which the user is concerned. As well, the analysis year (year for which the dollar values are calculated) is also presented. The zone in which a transfer is being considered is also presented along with the various zones that have been assigned by the user to the transfer station; if no transfer station is used then a zero is entered and no zones using the transfer station are listed. The last line identifies the lowest cost option number and that particlar total system cost on an annual cost basis.

The next question asked of the user is: DO YOU WANT A COST SUMMARY BY ZONE (Y OR N)? The user simply types "Y" and presses ENTER to receive a copy of the annual costs for each system option by zone. A sample of this report is presented in Figure 1.32.

The report presents the annual transportation related cost for each of the 20 collection system options for each zone. In addition the zone population is presented and the least cost option number is identified. A zero simply means that this option is not applicable, particularly when a transfer station is not being considered. The year of the population data is also presentd along with the analysis year (in the example the forecast 2001 population data has been used and all costs are in 1987 (analysis year) dollars).

At this point the best collection and site system has been determined by the SWAT Model. The user, at this point, can accept the identified system or continue to consider the qualitative factors presented in Section 1.2.3 of the report. This is a separate, manual procedure that the user must incorporate as part of the process at their own discretion. As well, the user may look at a different central disposal site, consider various population projections, transfer station options or

SOLID WASTE TRANSPORTATION MODEL

COMMISSION: SANFLER

DATE: 1980/1/10 10:37

SUMMARY OF ANNUAL COSTS FOR EACH SYSTEM OPTION BY ZONE ($)

ZONES	POP	LEAST COST	OPTIONS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1239	8	57152	49860	32491	36279	417979	32201	32791	27679	44538	39426	49905	50387	50476	51066	62813	0	0	0	0	0
2	3451	3	59669	44644	38451	48652	113038	61081	61103	46189	61278	46284	112086	112080	111477	111579	111674	0	0	0	0	0
3	773	3	32719	24028	13192	14297	147207	21245	21665	16514	30019	24068	27750	28063	27910	28329	36684	0	0	0	0	0
4	899	8	26256	20289	16429	18708	111501	20509	20784	16008	26267	21571	30550	30710	30362	30637	36120	0	0	0	0	0
5	1223	3	23201	16279	15115	15019	32836	25016	25114	18178	27074	20138	36145	36137	35529	35628	37508	0	0	0	0	0

POPULATION YEAR: 2001
ANALYSIS YEAR: 1987
TRANSFER STATION ZONE # 0
OTHER ZONES USING TRANSFER STATION

FIGURE 1.32

carry out sensitivity analysis by varying the input to the model databases. A complete SWAT Model computer run is presented in Appendix II, including user input and report results for the various model procedures.

SECTION 1 - REFERENCES

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SECTION 2

POLICY GUIDELINES
ECONOMIC CONTRACTING OPTIONS

2.0 POLICY GUIDELINES - ECONOMIC CONTRACTING OPTIONS

2.1 Introduction

In the Fredericton region, the Department of Municipal Affairs and Environment negotiated three year contracts with local haulers for collection of waste in the rural areas within the commission boundaries. A number of concerns were raised as a result of this exercise, and the Province is interested in determining the direction future commissions should take in regard to rural collection. To address this issue, we examined the two basic options: (i) negotiating a price with existing haulers, or (ii) call tenders for the collection services. Specifically, the following were addressed:

1. Potential cost savings when tendering collection services.

2. The impact on long-term costs if contracts are tendered, i.e., lessening of competition by eliminating the small haulers.

3. The major advantages and disadvantages of the two approaches.

4. Which option provides the most flexibility in terms of accepting the various types of waste (i.e., bulky waste, garden waste, Christmas trees, refrigerators, stoves, etc.).

2.2 The Existing Collection Contracting Situation

The internal report completed by the Department of Municipal Affairs and Environment, entitled "Rural Garbage Collection in New Brunswick," summarizes the existing collection contracting

system in New Brunswick as of February 1987. Data is presented relating to both the municipal collection system and the rural or local service district (LSD) system.

2.2.1 Urban Areas

There are 117 municipalities (cities, towns and villages) in the Province of New Brunswick. There are basically three methods of contracting/receiving garbage collection services within these various municipalities: tendered contracts, private haulers or municipal employees. Tendered contracts imply that the municipality (or local service district) tenders for the garbage collection services and coordinates the collection service. The waste collection is paid for by taxes from the residents located within the particular area served. Private haulers, on the other hand, contact individual householders and they make an agreement between themselves with respect to charge rate, collection day, type of acceptable domestic waste and other general requirements. In this case the waste collection service is not coordinated by the municipality (nor local service district) and no taxes are used to cover the cost of domestic waste collection and disposal. The third case is where municipal employees actually carry out the waste collection and disposal service themselves. In this case the municipal taxes pay for the waste collection.

Of the 117 municipalities in the Province, 36.8 percent use tendered contractors (or major tender contractors who may have negotiated future contract extensions), 40.2 percent use private haulers (who basically contract through negotiations with individuals), 17.9 percent use municipal employees and another 5.1 percent have no formal collection service. In the latter case, individual home owners are responsible for disposing of their

domestic waste. The following Figure 2.1 shows this distribution graphically. The private haulers represent the portion shown as negotiated contracts; however, they would differ considerably from negotiated contracts with municipal councils or regional solid waste commissions. Presently in those municipalities where waste collection is left up to private haulers, not all of the households in the municipalities use the service. This would not be the case where a municipality or regional waste commission negotiated a contract with the present private haulers; the private hauler would have to service all homes and all home owners would be expected to use the service. Under this type of negotiated contract, tax dollars would pay for the service.

Summary cost data from the 1986 Annual Report of Municipal Statistics are presented in the report "Rural Garbage Collection in New Brunswick." Cost data was available for 66 out of the 117 municipalities in the Province. The summary statistics are restated in Table 2.1 with average costs presented for each method of collection contracting: tendered contract service, private haulers and operation by the municipality. Almost 58 percent of the municipalities, for which there are collection cost data, fall in the cost range of $5.00 to $15.00 per capita with about 34 percent between $5.00 to $10.00 and 24 percent between $0.00 and $15.00. However, the full range of collection cost varies anywhere from less than $5.00 to more than $30.00 per capita. This substantial range can be due to many variables. One of the key variables noted in other provinces is the population density in terms of households per kilometre of road being serviced and the relative distance to the central disposal site. Low density areas are more costly to service whether it be by tendered contractor or private hauler. Other factors include such things as utilization of the service, the amount of

Figure 2.1

WASTE COLLECTION CONTRACTS

PERCENTAGE BY TYPE – URBAN AREAS – 1986

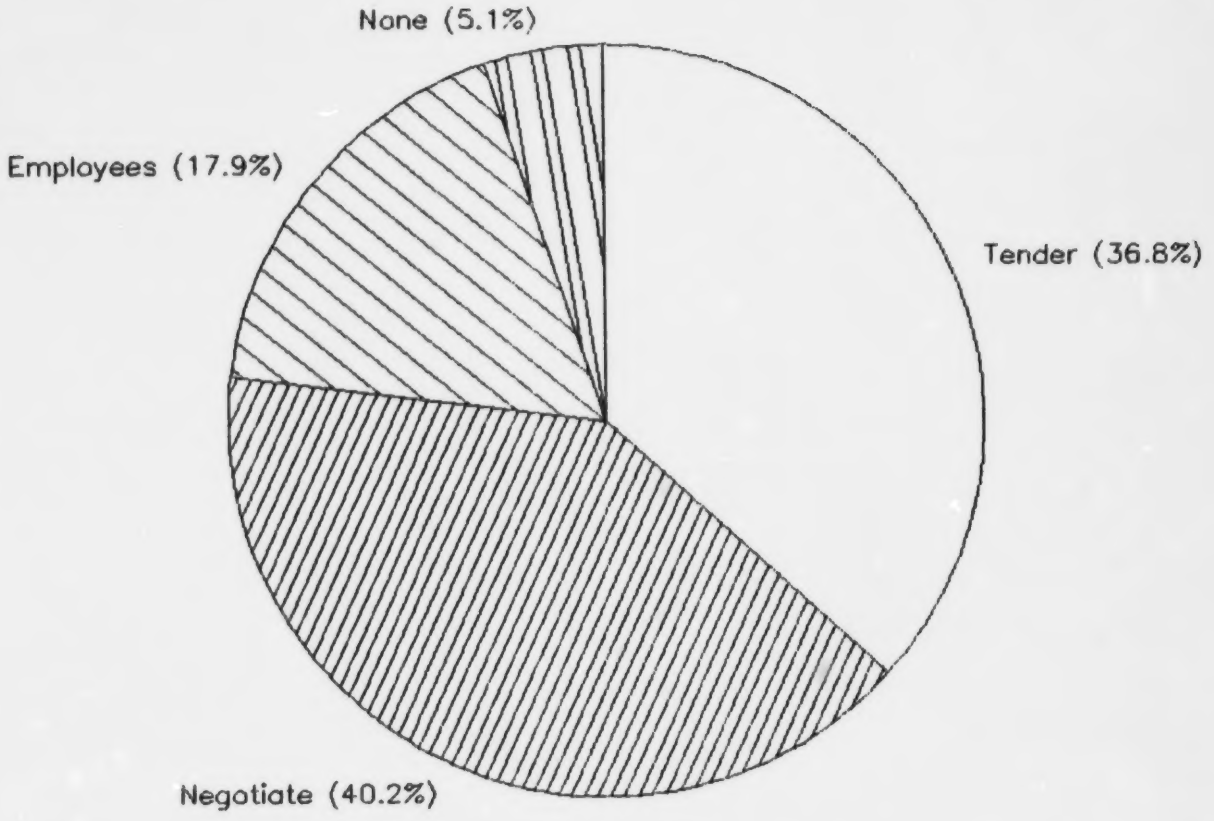


TABLE 2.1

ANNUAL MUNICIPAL GARBAGE COLLECTION COSTS
IN NEW BRUNSWICK

Range ($ per capita)	Number of Municipalities
Under 5.00	9
5.01 - 10.00	22
10.01 - 15.00	16
15.01 - 20.00	8
20.01 - 25.00	8
25.01 - 30.00	2
More than 30.00	1

Method of Contracting	Average Cost ($ per capita)
Tendered Contract Service	12.49
Private Haulers	27.27*
Operated by Municipality	12.00

*estimated only

competition and whether the competition really wants to service a low-density, more distant area and the type of collection system being used. Private haulers, for example, deal with individuals in an area as opposed to contracting for the whole area and as a result, all home owners do not necessarily use the service. Inherently this will increase the per capita cost. Type of collection system is important to the deterioration of price as well; low-density areas, serviced by private haulers who could deliver to container sites or a transfer station, could probably receive a lower price than the case where the private haulers have to deliver directly to a distant central disposal site.

The overall average cost for servicing a municipality where a tendered contractor is used is approximately $12.49 per capita. The cost is comparable for municipalities where the garbage collection is operated by the municipality itself at about $12.00 per capita. These costs are both substantially lower than the average cost of $27.27 per capita estimated for operation by private haulers.

It should be noted, however, that the above estimated cost, representative of private haulers, is only an order-of-magnitude estimate. The statistics presented in the 1986 Annual Report of Municipal Statistics are a little misleading for the cost of domestic waste collection when the municipality is being served by a private hauler; the municipality does not coordinate the collection service and therefore has no absolute knowledge of the cost of the collection service. The amount appears to be included in their budget for administrative budget allocation and funding and provincial cost-sharing purposes only; the tax dollars do not pay for the collection of domestic waste.

Therefore, these particular statistics could not be used. The report "Rural Garbage Collection in New Brunswick" did include an order-of-magnitude figure of $27.27 per capita where private haulers collected the domestic waste. This was not based on a statistical sample of households throughout the province, but rather on discussions with various municipal and local service district staff who used private haulers in their area. They had indicated the majority of households paid between $5.00 and $10.00 per month for collection. Assuming an average of $7.50 per month and using an average household size of 3.3 persons, the $27.27 per capita collection cost was derived.

Keeping the relative accuracy and range of the cost estimate for waste collection services in mind, it would appear that the best option in municipalities is to use tendered contractors. This conclusion should not be construed to mean that tendered contracting is always the route to follow. It should also be pointed out that there may be a significant difference between a negotiated contract arranged through a government (provincial or municipal) department with a private hauler and an agreement between an individual and the private hauler. On an individual basis the collection contractor is quite often not given the opportunity to service all homes in an area (in order to achieve economies of scale) and is continuously trying to maintain or expand his business by adding another customer to his list. In the former case the service area (and number of households) is a given and the collector is required to collect garbage at each and every home in the area (and any future homes in the area) during the length of the contract. Likewise, each of the home owners is expected to use the waste collection service. Obviously the econmies of scale could be quite different under these two different circumstances. In fact, some of the municipalities that were considered to be serviced by tendered contractors were actually being serviced by negotiated contractors.

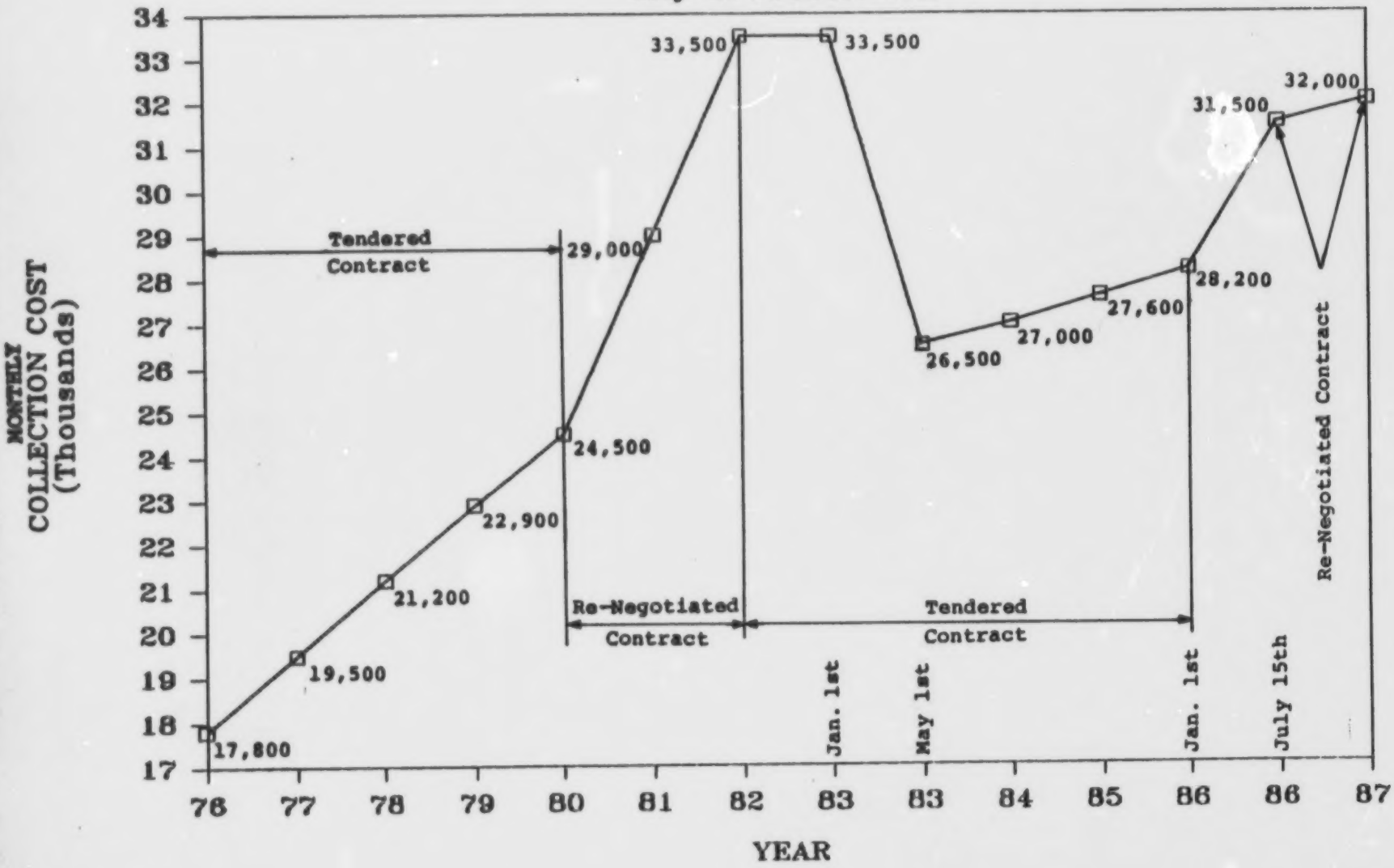
The City of Fredericton is one example where the municipality hs been alternating between tendered and negotiated contracts. In the above analysis they were considered to be using tendered contractors for the collection service. The negotiated contracts, in this particular circumstnace, were negotiated extensions of previously tendered contracts. The rationale for negotiated contracts was continued good quality of service and the financial negotiations included adjustments to account for inflationary increases and housing development growth.

Figure 2.2 depicts the monthly garbage collection costs for the City of Fredericton between 1976 and 1987. In this ten year period the type of contract alternated between tendered contract and renegotiated contract. The initial contract in 1976 was a tendered contract covering a five year period to 1980. During this period the monthly collection cost increased at about $1700 per year or about 38 percent over the five year period. The next contracting period covered approximately 2½ years. This was a negotaited contracting period in which the average monthly increase was $3600 per year or an increase of approximately 37 percent in 2½ years. During the negotiated period the annual increase in monthly collection costs were double that experienced during the previous tendered contracting period. In May 1983, the City again went to tendered contract. The result was an immediate drop of 21 percent in monthly collection costs. The next 3 year period during the tendered contract the annual increase in monthly cost was only $600. It should not only be noted that this is a substantially lower rate of increase compared to the negotiated period, but that it is also considerably lower than for the original tendered contracting period between 1976 and 1980. This would make one question whether, in fact, there is an advantage of consistently going with either a tendered or negotiated contract. If one were to extrapolate the rate of increase found between 1976 and 1980 (tendered contracting period) the monthly cost would have been in the order

Figure 2.2

GARBAGE COLLECTION COSTS

City of Fredericton



of $35,000 per month by 1986 compared to $28,200 actually experienced. This would indicate that maybe the best strategy is to alternate between tendered and negotiated contracts every three years. Figure 2.2 does show that when the initial contract is negotiated there is a tendency to have a higher rate of increase than that experienced when tendering.

2.2.1 Rural Areas

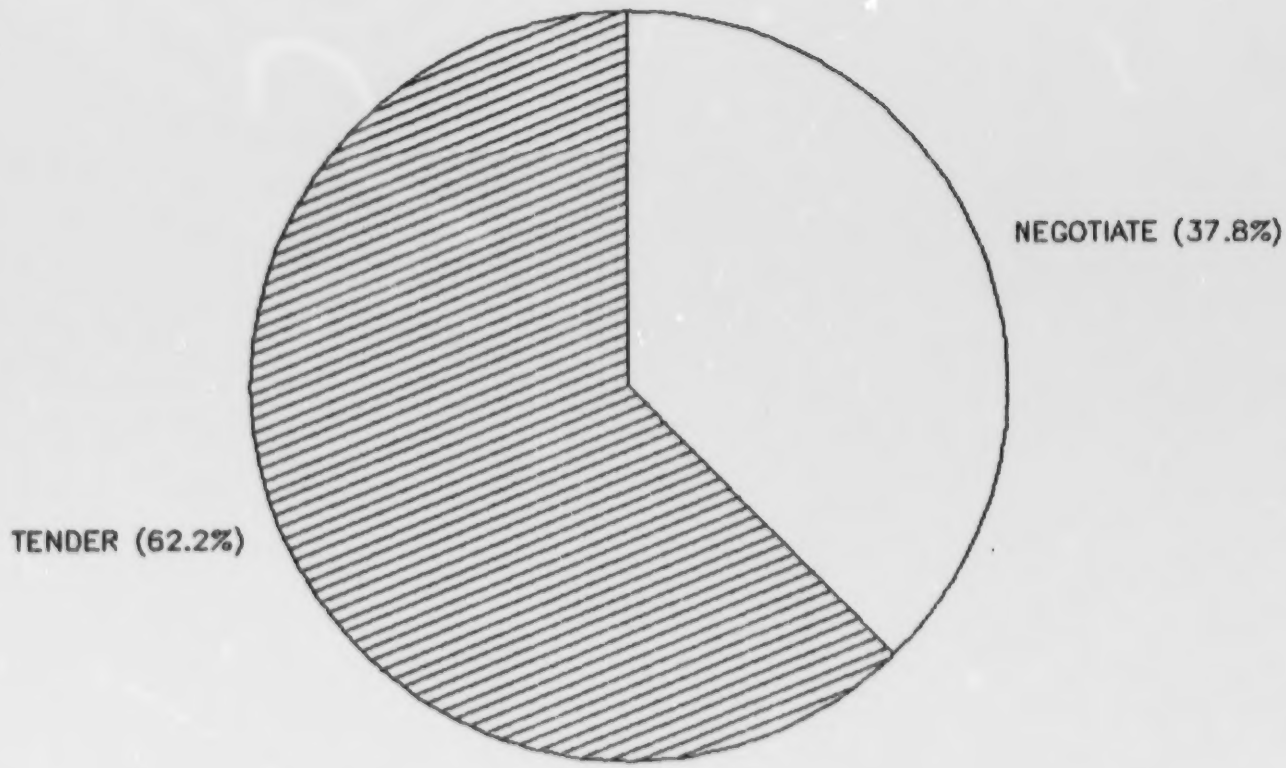
The rural areas of the Province are generally represented by local service districts. In 1985 there were 37 local service districts in New Brunswick; the rural domestic waste collection systems presently in place serve most of the LSD areas. Of the 37 LSDs, eleven serve complete parishes and the remainder service the various areas within the parishes. Twenty-three, or 62.2 percent, have tendered contractors provide their domestic waste collection service and the remaining 37.8 percent depend on private haulers to provide their collection service. The following Figure 2.3 shows this percentage split and again negotiated contracts refers to private haulers who make agreements with individual home owners as opposed to the local service district. Again, all home owners in a particular area may not use the services of a private hauler.

Some rural areas in the Province of New Brunswick can be sparsely populated and, as such, may not have the density of population to make it profitable for any contractor to service them. The distances to central disposal sites could, in a number of cases, be considerably greater than experienced in the municipalities and more urbanized local service districts. Low density areas may have to be combined with higher density areas for contracting purposes, or as an alternate container site established to help reduce the line haul costs to the central disposal site.

Figure 2.3

WASTE COLLECTION CONTRACTS

PERCENTAGE BY TYPE – RURAL AREAS – 1986



Summary domestic waste collection cost data from the report "Rural Garbage Collection in New Brunswick" is presented in Table 2.2. Only 17 of the 37 local service districts are represented in the compiled statistics. The majority of residents (59 percent) pay between $10.00 and $25.00 per capita. A significant percentage (24 percent) pay over $30.00 per capita. This is not unexpected as the rural areas in general have a lower density of development and therefore cost more to service. Average cost data in Table 2.2 indicates that the average cost for tendered contract service is approximately $42.38 per capita. After reviewing the data, two local service districts were found to be paying well over $100 per capita. Using Chauvenet's criterion for rejecting these outliers, the average tendered contract reduced to $15.95 per capita. The estimate for service by private haulers is again presented as $27.27 per capita based on the previously mentioned assumptions. With the outliers included in the database, tendered contracting service is higher than using private haulers. However, with the outliers removed, tendered contracting proves to result in the least cost per capita.

2.2.3 Experience in Other Provinces

As indicated in the report "Rural Garbage Collection in New Brunswick" a number of other provinces have some varied experience with domestic waste collection in the rural areas. In the Prairie Provinces there is a fair contrast in the type of collection service provided. In Alberta they have a relatively well established regional system of garbage disposal that has been operating for about 10 years. They have established Waste Management Authorities who administer and coordinate the construction of regional landfill sites, transfer stations and purchase of equipment. With their network of 115 container and transfer stations, they have only a few areas that actually have

TABLE 2.2

ANNUAL LOCAL SERVICE DISTRICT GARBAGE COLLECTION COST IN NEW BRUNSWICK

Range ($ per capita)	Number of Local Service Districts
Under 5.00	1
5.01 - 10.00	1
10.01 - 15.00	5
15.01 - 20.00	3
20.01 - 25.00	2
25.01 - 30.00	1
More than 30.00	4

Collection Responsibility	Average Cost ($ per capita)
Tendered Contract Service (with outliers)	42.38
(without outliers)	15.95
Private Haulers	27.27*

*estimated only

a rural waste collection service. The majority of residents deliver directly to container sites. Saskatchewan, on the other hand, operates over 950 dump sites with very few being engineered sanitary landfills. In the rural areas most people deliver their own garbage to the dump site.

The regional municipalities in Ontario are responsible for solid waste disposal and each municipality (city, town, village or township) is responsible for the collection of the domestic waste. The majority of townships in Ontario contract out their garbage collection service. The annual cost of contracting once-a-week garbage collection in Ontario ranges from $5.70 to $21.21 per capita with an average of about $12.56 per capita. This is comparable to the experience in New Brunswick with an average of $12.49 per capita in municipalities and $15.95 in local service districts. The wide range in per capita cost was attributable to the varying rural distances over which contractors must operate and the varied densities. The average cost given for a private hauler was $22.73 per capita which is comparable to the $27.27 per capita estimated for New Brunswick. Private haulers' rates were considerably higher mainly because they serviced the low population areas with low density. It would appear from this information that the higher cost does not result necessarily because a private hauler is used instead of a tendered contractor, but is more related to the economies of scale.

A review of the information available on the other Atlantic Provinces indicates that the collection and disposal systems in place are quite varied. Neither Prince Edward Island nor Newfoundland have an established system of rural waste collection. In Prince Edward Island there are six container sites provided for user delivery of domestic waste. Most communities in Newfoundland have some form of incinerator facility to which users deliver garbage. Nova Scotia, on the other hand, has

regional municipal governments that are responsible for administering and coordinating waste collection in their entire area. The regional municipality may be either a county or district which includes both municipal and rural areas.

About 68 percent of the regional municipalities use tendered contractors for rural garbage collection, 23 percent use private haulers and another 9 percent use their own employees. The range for garbage collection by tendered contractors was between $6.25 and $20.00 per capita with an average of $9.76. For private haulers the range was $12.00 to $26.00 with an average of $17.88 per capita; for operations where municipal employees provide the collection service the range was $7.50 to $9.10 per capita with an average of $8.30. The wide range in collection costs was again attributable to the variation in population density and total population served.

2.3 Contracting Options for Rural Waste Collection

2.3.1 General Contracting Options

There are two basic options for contracting domestic waste collection services in a rural area. They are:

1. Call for open tenders for the services; or
2. Negotiate contracts with existing waste haulers.

There are advantages and disadvantages associated with each of these options. The primary objective in either case is to obtain efficient and effective service at a reasonable price over the long term.

Some of the potential benefits attained through a tendering procedure are:

- competitive bids for the proposed collection service tends to ensure better prices, at least in the short term;

- a minimum number of contractors have to be dealt with provided a Commission Area is divided into only a few sub-areas, thus reducing the administrative overhead;

- with only a few contractors (or potentially one contractor) in a Commission Area, it is easier to standardize collection procedures, routing and scheduling;

- a limited number of contractors may result in improved economies of scale and thus reduced collection costs per household;

- tendered contractors may have better and more reliable equipment and experience.

Some of the potential disadvantages include:

- if one tendered contractor is chosen for an entire Commission Area, smaller contractors, including existing haulers, may not have the equipment and manpower to even respond, thus in the longer term may be forced out of business;

- if reduced competition results because smaller contractors cannot compete, then the tendered prices may actually be higher in the long run;

- even if sub-areas are chosen for which smaller contractors are able to submit a bid, a large contractor may be in a position to underbid in the short term to eliminate competition, and then increase the tendered price in future years.

The potential advantages associated with negotiating contracts with existing waste haulers are:

- existing haulers already have a knowledge of the territory and residents being served;

- they already know the amount of waste generated and seasonal fluctuations, and have worked out the most efficient routing and scheduling;

- because they are presently familiar with their customers, they may be able to better handle any complaints and may, in fact, have fewer complaints from residents because they are continuing an existing service that the residents have come to know;

- depending on the size of operation, they may have a lower overhead and therefore can provide the service at a lower price than could be obtained through the tendering procedure (however, they would not be able to compete in a tendering procedure where large sub-areas would have to be serviced simply because of their small size of operation).

The possible disadvantages with negotiating contracts include:

- higher administrative costs associated with dealing with a greater number of haulers;

- the larger number of haulers also may make it difficult to establish a uniform, consistent standard of collection within the Commission Area; therefore, residents may complain about unequal or poorer service when compared to another sub-area;

- if negotiated contracts are continued over the long term, the existing waste haulers may tend to increase prices because of the lack of, or perceived lack of, competition. However, this is offset, to some extent, by the fact that the regional commissions are dealing with a number of haulers and therefore can compare prices and services within their region.

In order to better evaluate the advantages and disadvantages associated with each of these options, we completed a survey of government and private industry representatives. The survey was designed to get qualitative ratings of the potential advantages and disadvantages associated with tendered contracts and negotiated contracts.

2.4 Collection Contracting Survey

The above section outlined some basic advantages and disadvantages associated with each of the contract types: negotiated and tendered contracts. To better weigh the relative importance of these potential advantages and disadvantages a waste collection contracting survey was completed. The survey was based primarily on the Fredericton Solid Waste Commission area because this particular regional commission has already gone through the process of establishing a central disposal site. Subsequent negotiations with existing private haulers were undertaken by the Department of Municipal Affairs and Environment. In addition, the City of Fredericton had some direct experience with both negotiated and tendered contracting.

Various private contractors, municipal staff, regional landfill comissioners and provincial staff representatives were interviewed by telephone. The majority of interviews were within the Fredericton area. However, two extra-provincial representatives were contacted as well: a representative of the Metroplitan Authority of Halifax in Nova Scotia and a representative of the Department of Environment in Prince Edward Island.

The interview form used is shown in Figure 2.4. The various questions were used as a guide and expanded upon by the interviewer as necessary to clarify any points.

The following categories of people were surveyed.

Government	
Provincial	- 3
Municipal	- 3
Regional Landfill Commissioners	- 2

Contractors	
Small	- 3
Medium	- 2
Large	- N/A

The following questions were related to the contractor and his business. The contractors themselves were classified as follows.

0-4 employees (small)
5-14 employees (medium)
15 and up (large)

2.4.1 Characteristics of Contractors Interviewed

The percentage of negotiated versus tendered business varied from contractor to contractor, generally depending upon the number of years they had been in operation. Those who were new to the business had either 100 percent negotiated or 100 percent tendered, while some of the more established solid waste haulers varied from an 80 percent negotiated and 20 percent tendered to 80 percent tendered and 20 percent negotiated.

FIGURE 2.4

SOLID WASTE COLLECTION SURVEY
PROVINCE OF NEW BRUNSWICK
TELEPHONE SURVEY

1. **NEGOTIATED CONTRACTS**

(a) Advantages

1. Existing haulers are familiar with territory and clientele?
2. Determined most efficient routing and scheduling of seasonal fluctuations.
3. Good rapport with current customers.
4. Depending upon size of Company, there could be lower overhead cost, which means lower prices than by Tender.
5. Until people are familiar with regional landfill, allows small contractors to adapt.
6. Other _____

_____

_____

(b) Disadvantages

1. Higher administration costs.
2. Harder to establish a uniform, consistent standard of collection.
3. If perceived competition is not there then prices will increase.
4. Other _____

_____

_____

2. **TENDERED CONTRACTS**

(a) Advantages

1. Competitive bidding ensures lower prices in short term.
2. Administration costs lowered due to decrease in number of contractors.
3. Easier to standardize collection procedures, routing and scheduling because of fewer contractors.
4. Cost/household could be lower because of scales of economies.
5. Tendered contractor may be more reliable because of spare equipment and more staff.
6. Other _____

_____

_____

(b) Disadvantages

1. Reduces the number of available contractors.
2. Thus, Tender prices may be higher in the long term.
3. Larger contractors may be in the position in the sub-areas to underbid the smaller contractors.
4. Other _____

_____

_____

3. In your overall evaluation, do you prefer:

(a) Negotiated _____

(b) Tendered _____

Why? _____

_____

4. If there were to be a mix of negotiated and tendered contracts, where are:

   (a) Negotiated contracts most appropriate? _____

   _____

   (b) Tendered contracts most appropriate? _____

   _____

5. Current job position in the solid waste collection business:

   Administration: Provincial |___| _____

   Municipal |___| _____

   Other |___| _____

   Contractor: 0-4 Employees |___| _____

   5-14 Employees |___| _____

   15 and up |___| _____

6. Current type of Contract: Negotiated _____%
   Tendered _____%
   Other _____%

7. Duration of Contract: _____ months

8. Total value of Contract: $_____

9. Category of area served: Urban _____%
   Rural _____%

10. Equipment Utilization

	Vehicle	Capacity	Manpower	# of Households per Load
1.				
2.				
3.				
4.				
5.				

11. Are you satisfied with the present arrangement? (i.e., Negotiated Contracts)

_____

_____

12. What do you, as a contractor, feel is a fair contract period?

_____ months

Why? _____

_____

_____

All the contractors felt that 36 months was the minimum for contract length, as this gives them an opportunity to amortize their equipment, and the banks or other financial sources are easier to deal with when the contractors have longer term contracts. The contract size ranged from $22,080/annum to $320,000 /annum.

The area served varied as well, from 100 percent urban to 100 percent rural with the mix being as much as 50-50 split for some contractors.

The trucks used varied in capacity, manpower requirements and volume/load. The smaller contractors use the ½ ton to 1 ton range while the larger contractors use the compactor trucks (20-30 yd^3) with rear loading. In discussion with one contractor, the side loading vehicle appeared to have large manpower savings over the rear loaders and they were pursuing this option.

2.4.2 Observations and Conclusions

In completing the telephone survey for the solid waste collections study there were opinions and concerns expressed by representatives from various levels of government, as well as private industry. In review of the interviews, the responses were open and honest and the respondents generally reinforced their position on any issue with comments regarding the aspects that they felt were pertinent. The issues varied from person to person, but only slightly, in most cases. The following generally provides the results of the survey on a question and answer basis.

I. Negotiated Contracts

(A) Advantages

1. There was general agreement that the existing contractors are familiar with the territory and clientele; however, some respondents qualified their answer with the comment that the new contractors would become familiar with the market very quickly.

2. The second advantage, that existing haulers have determined the most efficient schedules and routes, was agreed upon by 100 percent of the contractors and 63 percent of the government representatives; again, this was qualified with a statement that where another contractor with different equipment were to take the routes their schedules may be altered simply to gain the advantages in efficiency (e.g., hauler with 1 ton truck versus contractor with a 20 cubic yard compactor truck).

3. There was 100 percent agreement that if the existing contractor has a good rapport with the customers and is doing a good job that this is a good reason for a negotiated contract.

4. There was general agreement (80 contractors, 75 percent government) that size of the contractor affects amount of overhead and resulting collection prices. The conclusion was that there is a direct relationship between overhead costs and volume of work, that in fact the smaller contract could cost more per capita. An important aspect other than cost is the quality of service; the smaller contractor who negotiates a contract may give a higher standard of collection, and a more personalized service. Another concern

raised was the overhead related to the amortization of the equipment, and this is directly related to the term of the contract.

5. The fifth advantage to negotiated contracts was the ability for existing haulers to adapt to radical changes in the solid waste collection system (i.e., the implementation of a regional landfill and requirement for the roadside collection of garbage at all households). Customers are generally wary of change, and the negotiated contract was definitely viewed as the fairest alternative in this situation.

In general comments, other advantages raised by the respondents for the negotiated contracts are as follows.

6. Where a contract extension is required for a short duration, a negotiated contract allows you time to adjust your tender.

7. Changes in routing or scheduling can be done easier on a negotiated as opposed to a tendered contract, generally.

8. The performance and stability of the contractor is generally a known factor. This may be important to the political climate in smaller communities.

9. Negotiated contracts maintain a good resource of contractors in the event a single contractor gets into trouble. Also, local contractors keep the money in the local economy. Competition, in recent years, has been increasing to include national collection contractors for a number of tendered contracts.

10. The final observation under advantages of negotiated contracts is that the small contractor has generally built up the business under his own initiative, and it provides him the opportunity to hold on to the business. In many cases the smaller contractor's survival may depend on these contracts. The larger contractor prefers going to tender to acquire more contracts with the ultimate goal of eliminating the smaller contractors. The larger contractor views the tender system as the most fair and equitable.

(B) Disadvantages

1. Higher administration costs is true with negotiated contracts only if a large number of smaller contractors are involved. The contractors agreed 80 percent while government officials agreed only 63 percent, that administration cost would probably be minimal. Every respondent felt there would be no requirement to hire staff, as an existing employee could manage the administration of the collection system.

2. It was generally agreed that it may be harder to establish a uniform, consistent set of standards for collection, but only marginally so. In fact, some respondents felt that with the negotiated contract and the smaller contractor being involved a better standard of collection would be attained. The small contractor will probably have personal pride involved in the job, coupled with the fact that the government currently has a set of 22 guidelines (i.e., contract requirements) that must be addressed by all solid waste haulers.

3. The final disadvantage to negotiated contracts was that if competition was not perceived then the prices would climb, and this was generally agreed to without many comments. The thought arising here was that garbage collection is not technically oriented, so that before prices would climb drastically other contractors would enter the market.

Other general comments under disadvantages were as follows:

4. Prices plus costs may be higher with negotiated contracts, but the quality of service, dollar value and customer satisfaction will probably be greater.

5. The government officials' opinion was that the negotiated contract would not obtain the best price that the marketplace had to offer. This assumption was based upon large tender packages in which there would be large scales of economy. If the tender packages were small then smaller contractors may do the job less expensively, especially if the contractor is a local resident.

6. Another disadvantage is the threat of government patronage which over time may creep into the system. The tender call has the appearance of being fairer.

7. Sometimes a working relationship between contractor and owner will deteriorate, and a friendship formed so that the owner is reluctant to enforce regulations on the contractor. The tender contract provides the owner the opportunity to re-evaluate his contract definition and enforce them so that the job is done properly.

II. TENDERED CONTRACTS

(A) Advantages

1. The advantage that competitive bidding ensures lower prices in the short term was accepted; however, the general opinion was that the best price would be achieved through tendering, whether short-term or long-term. Also the size of tender would have an impact on the price.

2. There was general agreement that the administrative costs should be lower with tendered packages, yet there was widespread doubt that this would be the actual fact. Some felt that, with tendered contracts, the quality of service could potentially decrease dramatically, and then administration cost would go up with an increase in the number of complaints. They basically see the tendering process as a means of getting the contractor with the lowest cost (bid) and not necessarily receiving or maintaining a good quality of service.

3. The tender size and the contractor's equipment will determine the most efficient routes and schedules. This may be a disadvantage depending on how it is handled, for with the larger contractors, the rescheduling for snowstorms, etc., becomes a more difficult task and increases administrative costs. Generally, small contractors look after their own rescheduling with minor problems.

4. There was agreement that the cost/household should be less with a tendered contractor; however, the concern expressed by the small contractor is that in order to service the extreme fringe areas (e.g., Zionville with a very rural population) they require a larger portion of the complete

market. If the larger contractor acquires the high density zones in and around the City, who will service the extreme fringe areas. Probably there would not be adequate volume to make it economically viable when only servicing the fringe areas, and the larger contractor will find it difficult to service these areas with the larger equipment. Typical examples of inefficiencies when operating in the fringe areas are the heavier trucks operating on gravel roads in the springtime, and the overall inefficiency of running a larger truck to service a small number of homes spread out over a large area.

5. The general response to the suggestion of greater reliability of tendered contractors was disagreement, and this is because the smaller negotiated contractor is required to have backup equipment and manpower as well as the tendered contractors.

There were no other distinct advantages noted, but rather some general comments which are covered in other portions of the survey.

(B) Disadvantages

1. & 2.
Eighty-five percent accepted the fact that the tendering process would reduce the available number of contractors and that tender prices could be higher in the long term. Again this would be influenced by the size of the tender package and the contract definitions. There was concern raised that subcontracting could develop; however, when considering the technical complexity of garbage collection it is reasonable to believe that as the prices increased, then new contractors would enter the market.

3. There was 100 percent agreement that the larger tender contractors could be in a position to underbid the smaller contractor; however, this would depend on tender size and makeup.

4. Another disadvantage to the tender contract is that if population growth is substantial then the contractor could be in a position of financial loss, again contract definition is an important consideration here.

5. It would be more difficult to reschedule or have special pickups when there are only 1 or 2 large contractors involved. They are generally very busy, and it is much more difficult for them to make changes because of tight schedules and larger areas to be served.

III.

In the contractor's overall evaluation of the system, they preferred the negotiated contracts. They would admit that probably a better price could be achieved by tendering, yet most of them felt that the quality of service would also diminish.

The government and administrative personnel all favoured the tendering process. A number of the respondents did express a concern for the quality of service, and they were concerned about the issue of possible political involvement, if the bids were not tendered.

IV.

The response to the mix of tenders was unanimous. In the high density areas all agreed the tender price is probably going to give you the best result, while in the smaller fringe areas a

negotiated price with the small local contractor will probably be the most efficient, with the general rationale being pride and image in the community. The size of the contract is important, as it must be economically viable for the small negotiated contractor. The small contractor who views garbage collection as a weekend job, or evening job, will win the extremely small fringe area contracts. The weekend contractor tends to be more expensive and will have a totally different attitude than the contractor who is deriving his livelihood from solid waste collection. Therefore, tender package size is extremely important.

2.5 Recommended Policy Guidelines

Municipalities are responsible for their own domestic waste collection services; therefore the following policy guideline recommendations for choosing the type of contract for collection services are primarily applicable to the rural areas. The basic objective in either case is to decide whether to negotiate contracts or call tendered contracts.

General Contracting Restrictions

One major determinant of the type of contract to be implemented should be the analysis of the solid waste transportation costs and collection options evaluation. The solid waste and transportation (SWAT) model can be used to cost the various collection options available to an area (or zone) within a Regional Commission or external to the commission. The SWAT model is not intended to cost the options to an accuracy that one could predict exactly what a negotiated or contracted collection cost should be, but should provide a relative comparison of options. This then should indicate whether the collection system presently being used by a contractor (private hauler, negotiated or tendered contractor) is the most cost-effective.

The SWAT model results may indicate that a collection system quite different from the one in place should be utilized, particularly if the main objective is to minimize the cost of domestic waste collection and delivery to the central disposal site. Where there is such a difference, the existing contractor may not be appropriately equipped to accommodate the best collection option. Under these circumstances the tendering process would probably provide the best alternative as the existing contractor is not really in a position to accommodate the recommended collection system.

The tendering procedure does not prevent the existing contractor from submitting a bid for the collection services, but it does mean that his bid would have to be competitive with others that may better accommodate the recommended collection system.

The general recommendation is also made that any contract, whether negotiated or tendered, be for a minimum of three years. The terms of the contract should be such that the rural area is assured, not only a reasonable collection price, but also good quality of service, reasonable value for the dollar and customer satisfaction for the full term of the contract. A three year contract is important from a financial perspective in order that the contractors have a reasonable length of time over which they can amortize their costs and in order to obtain capital from banks and other sources.

Neither the pricing comparisons of negotiated and tendered contractors (in many cases actually private haulers versus tendered contractors) nor the results from the waste collection survey prove conclusively that one contract type is superior to the other and applicable in all circumstances. The decision has to be a function of the physical and economic restraints including consideration for:

- remoteness from the central disposal site;

- household density and total number of households to be served;

- the size of the market or the number of areas to be served; and

- the availability of waste collection contractors to make the tendering process viable.

In high density areas the economics of scale will mean, in general, that the tendering procedure is probably the best because more contractors would generally be available, a number of contractors would want the business and the best price would be received while still being assured of a reasonable quality of service. In the smaller fringe areas a negotiated price with a small local contractor would probably be the most efficient since larger contractors do not, in general, want to serve more remote, low density areas and, as a result, would be less likely to compete for those collection services and the local contractor would normally have greater pride in the smaller community and tend to be more concerned with personal image in the community as well. This may be particularly relevant when first establishing the regional commission areas; in a number of cases the existing collection is either done by a combination of the individual user and a private hauler implying that there is really no existing competition to support the tendering process.

Negotiated Contracts

Negotiate with existing waste collectors where:

Type I - existing haulers originally won a tendered or negotiated contract

1) If existing collection cost per capita per year is equal to or less than the average cost being experienced for the household density found in similar areas of the province;

2) Where the negotiated rate increase per capita does not exceed the inflation rate; the total contract price might be higher to account for new and future housing development in the serviced area;

3) If there are a sufficient number of existing haulers to service all areas with an acceptable quality of service; that is, they must be willing to service the very low density areas as well as the high density areas with the same level of service and with the proper equipment.

Type II - existing haulers who originally developed the business by contacting individuals on their own and agreeing on a collection rate between them

1) If existing collection cost per capita per year is equal to or less than the average cost being experienced in other areas with similar household density; existing haulers must be willing to reveal their existing rates per capita;

2) Where the negotiated rate does not exceed the inflation rate and the final contract price allows for new and future housing development that is proposed for the contract period;

3) Where the existing hauler has a good track record for providing an acceptable quality of service and using the proper equipment to do the job properly and there have been a minimal number of complaints; and

4) If the existing hauler presently services 75 percent or more of the households in the area and is willing to service the remaining households at the same rate or better per capita as he presently charges plus an amount less than or equal to the present inflation rate.

Tendered Contracts

Tendered contracts should be called where:

Type I - one tendered contract or a substantially reduced number of tendered contracts will be arranged to service all the rural area(s)

1) Where the rural areas are not presently served by any waste collectors and the density is such that different areas have to be combined to make any waste collection system economically viable;

2) Where existing areas are being served by more than one collector and when combined because of gains in collection efficiency make the competitive bidding procedures feasible; and

3) If the collection system determined to be best for the area (e.g., using the SWAT model) requires that the existing collection system be replaced and the existing collectors are not in a position to meet the new collection requirements.

Type II - separate tendered contracts are called for smaller rural areas

1) Where the household density and total number of houses to be serviced is relatively high and there is existing competition for the domestic waste collection services through different private haulers (who presently may be servicing different routes, but in essence are really servicing the same area);

2) Where the negotiated prices would be higher than the average cost experienced in other areas of similar density and total market;

3) If there have been a number of complaints with respect to the quality of service being provided; and

4) If the existing haulers do not conform to provincial regulatory requirements nor meet safe operational requirements as generally found acceptable to the Department of Municipal Affairs and Environment.

SECTION 2 - REFERENCES

1. "Rural Garbage Collection in New Brunswick," Province of New Brunswick, Department of Municipal Affiars and Environment, February 1987.

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4. Solid Waste Haulage Agreement, Province of New Brunswick, Draft Version, 1987.

5. "Contracting Refuse Collection - Case History," Peter S. Connell, Director of Engineering and Works, City of Halifax, 1986.

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SECTION 3

SAFETY CONSIDERATIONS RELATED TO SOLID WASTE COLLECTION

3.0 SAFETY CONSIDERATIONS RELATED TO SOLID WASTE COLLECTION

3.1 Introduction

An integral part of the provincial waste management program involves the collection of domestic waste in the rural areas of the Province of New Brunswick, inside and outside Regional Commission areas. As a result, serious consideration must be given to identification of existing and potential safety problems, particularly when, in many cases, posted speeds are 70 or 80 kilometres per hour or more.

Curbside or roadside solid waste collection operations can be defined as work activities where workers and equipment move along the road or street at a very slow speed with intermittent stops made at each household for actual collection of the waste. This is basically a short-term utility operation; however, as it occurs in the travelled lane every effort must be made to warn other traffic of the hazardous situation. Generally speaking, in urban areas the work vehicle may be used for warning if it is equipped with flashing lights, rotating beacons and/or flags.

The report "Rural Garbage Collection in New Brunswick" indicates that the New Brunswick Health and Safety Act does not address safety issues related to rural garbage collection. Generally speaking, there are no specific records indicating accidents involving garbage trucks to date. Vehicle types are not specifically identified on accident forms. However, a number of complaints have been received by the Department of Transportation. Complaints include collections vehicles not being properly equipped with lights, pulling out in front of cars, waste collection staff and vehicles wandering from one side of

the road to the other in order to collect domestic waste from both sides of the road and garbage falling off uncovered collection vehicles.

Our approach has been to review existing regulations and/or policy guidelines available from various provincial departments regarding the operation of their slow moving vehicles (examples include snowplows, surface patching vehicles and crews, testing vehicles and crews and construction vehicles). Safety regulations for waste collection vehicles in other provinces were also examined. Our review will be centered around four main considerations:

- vehicle signing and operation;
- personnel operational requirements;
- highway geometric considerations; and
- off-highway considerations.

3.2 Safety Requirements Evaluation and Needs

Various provincial governments and major cities in Canada were contacted to determine what, if any, existing regulations are in place to control the safety aspects of solid waste collection operations. Surprisingly, very few regulations or written guidelines were available. The various jurisdictions appear to recognize the potentially hazardous situation that exists for both the collection personnel and collection vehicle, but no actual action has been taken to produce any written policy guidelines. As a result, we had to review various reports dealing with various accident studies and the application of techniques for warning of slow-moving vehicles ahead.

We examined the various statistics that have been published to establish a relatively quantifiable measure of the seriousness of the solid waste collection operation in terms of the traffic operations and related safety considerations.

It is necessary for various vehicles operating at low speeds to utilize public streets and highways from time to time. This classification of vehicles includes farm tractors, other farm vehicles, road maintenance and construction equipment and other vehicles such as solid waste collection vehicles whose operational characteritsics require that they operate in the travelled lane at speeds well below 40 kilometres per hour.

Waste collection vehicles and crew members are working in a relatively hazardous environment. The report "Safety Aspects of Using Vehicle Hazard Warning Lights" provides various statistics to support this general observation. Studies in the United States have shown that in the order of 15 to 20 percent of all accidents involve two vehicles travelling in the same direction; the lead vehicle either stopped or was moving at a significantly lower speed. They also found that this represents over 40 percent of all two-vehicle, nonintersection accidents. In 1976, the National Safety Council reported in "Accident Facts" that 26 percent of all rural nonintersection accidents that involved two vehicles occurred when both vehicles were travelling in the same direction. Past research also indicates that one of the principal causes of such accidents was the speed differential between the two vehicles involved and that the probability of a higher speed differential increased if one of the two vehicles was a truck (or other slow-moving vehicle) on a moderate or steep grade.

Other relevant statistics are presented in the 1980 report "Safety Aspects of Using Vehicle Hazard Warning Lights" indicating the order of magnitude of the risk that could be anticipated with solid waste collection operations. Following is a direct quote from the study.

> "In a study of automobile rear-end collisions, Solomon (1964) found that 47 percent of the accidents had a speed differential between the vehicles of more than 20 mph (32.3 kph); only 7 percent of the normal traffic travelled with such speed differences. Other studies (Mitchell, 1966; Taylor, 1965; Research Triangle Institute, 1970) have concurred with this finding, suggesting that speed differentials between vehicles are the likely antecedent behaviour in rear-end and other same-direction collisions. Results of the Research Triangle Institute Study (1970) indicate that vehicles travelling more than 15.5 mph (25.0 kph) from the mean traffic speed were 12 times more likely to have a collision than were vehicles travelling within 5.5 mph (8.9 kph) of the mean speed. A vehicle pair travelling with a speed differential of 30 to 35 mph (48.3 to 56.4 kph) was 30 times more likely to be involved in a rear-end accident than a vehicle pair travelling with a speed differential of 15 mph (24.2 kph) or less."

Obviously with the solid waste collection operation being carried out in this potentially hazardous environment, safety measures should be taken with respect to the collection vehicle, the workmen and all operational procedures.

3.3 Existing Regulatory Requirements

From the review of Provincial Acts and Regulations, there are no specific regulations directed at solid waste collection vehicles in particular, although there are specific sections of regulations that are applicable to waste collection vehicles. Similarly, the Occupational Health and Safety Act makes general reference to safety requirements for workmen and employees, although none are directed specifically to waste collection

practices. Specific sections of Acts and Regulations are quoted below which are considered relevant to safety procedures required in the domestic waste collection operations.

3.3.1 Personnel Safety Regulations

Particular sections of the Occupational Health and Safety Act are considered applicable to the safety of personnel involved in the collection of domestic waste. Following are direct quotes from Chapter O-0.2 Occupational Health and Safety Act, Assented to August 5, 1983.

DUTIES OF EMPLOYERS, OWNERS, CONTRACTORS, SUBCONTRACTORS, EMPLOYEES AND SUPPLIERS

8 Every employer with twenty or more employees regularly employed at a place of employment shall establish and file with the Commission a safety policy in respect of that place of employment.

9(1) Every employer shall

(a) take every reasonable precaution to ensure the health and safety of his employees;

(b) comply with this Act, the regulations and any order made in accordance with this Act or the regulations; and

(c) ensure that his employees comply with this Act, the regulations and any order made in accordance with this Act or the regulations.

9(2) Without limiting the generality of the duties under subsection (1), every employer shall

(a) ensure that at the place of employment the necessary systems of work, tools, equipment, machines, devices and materials are maintained in good condition and are of minimum risk to health and safety when used as directed by the supplier or in accordance with the directions supplied by the supplier;

(b) acquaint an employee with any hazard to be found at the place of employment in connection with the use, handling, storage, disposal and transport of any tool, equipment, machine, device or biological, chemical or physical agent;

(c) provide such information, instruction, training and supervision as are necessary to ensure an employer's health and safety;

(d) provide and maintain in good condition such protective equipment as is required by regulation and ensure that such equipment is used by an employee in the course of work;

12 Every employee shall

(a) comply with this Act, the regulations and any order made in accordance with this Act or the regulations;

(b) conduct himself to ensure his own health and safety and that of other persons at or near his place of employment;

(c) report to the employer the existence of any hazard at the place of employment of which he is aware;

(d) wear or use such protective equipment as is required by regulation.

In addition, a couple of sections are quoted from Regulation 77-1 under the Occupational Safety Act:

10(12) Employees shall wear CSA Approved Class B, Type 2, safety hats, or equivalent, on all construction project sites or on any other place of employment where there is a hazard which may cause head injuries.

10(13) Employees shall wear CSA approved footwear, or equivalent, on all construction project sites or on any other place of employment where there is a hazard which may cause injuries to the feet.

The above regulations and safety procedures indicate the responsibility of both employer and employee in ensuring that the work is carried out safely. There is a requirement for safety

hats during garbage collection operations because the workmen are working around mobile equipment (the collection vehicle) and sometimes loading loose and relatively heavy waste material onto trucks (particularly during a cleanup period). Additional safety benefit can be achieved because they make the collection personnel more visible to other drivers on the road or street and are recognized as workmen whose direct attention may be on carrying out his duties rather than specifically watching for traffic. Again safety footwear is recommended as the collection crew are working around mobile equipment and collecting varied domestic waste.

3.3.2 Waste Collection Vehicle Safety Regulations

Although no specific sections of Acts or Regulations address the issue of transportation safety as it relates to roadside waste collection, there are sections that are applicable to waste collection vehicles. The operation of the collection vehicle must adhere to all requirements of the Motor Vehicle Act (O.C. 84-873) and various related regulations. Of particular relevance to the safety considerations is the following quote from New Brunswick Regulation 84-98 under the Motor Vehicle Act:

> Under section 231 of the Motor Vehicle Act, the Lieutenant-Governor in Council makes the following Regulation:
>
> 1 This Regulation may be cited as the Slow Moving Vehicle Sign Regulation - Motor Vehicle Act.
>
> 2(1) The slow moving vehicle sign to be attached to a farm tractor or self-propelled implement of husbandry and every vehicle designed for operation with speeds not in excess of forty kilometres per hour or any vehicle towed by them shall be in the shape of a base-down equilaterl triangle, fluorescent yellow-orange in colour with a dark red retro-reflective border and shall be of the dimensions and size as prescribed and illustrated in the following figure:

2(2) The sign referred to in subsection (1) shall be bonded to a durable rigid weatherproof-base surface.

2(3) The brightness of the retro-reflective border referred to in subsection (1) shall comply with the requirements of Schedule A.

2(4) The sign referred to in subsection (1) shall be mounted,

(a) base down in a plane perpendicular to the direction of travel of the vehicle; and

(b) where practicable, on the rear of the vehicle or combination of vehicles, at the centre of mass of the vehicle or vehicles, and not less than ninety centimetres nor more than one hundred and fifty centimetres above the roadway,

and shall be clearly visible for a distance of not less than one hundred and fifty metres from the rear of the vehicle or combination of vehicles.

3 The sign referred to in section 3 shall be free from dirt and obstruction and shall be so affixed as to be plainly visible at all times, and the view of the sign shall not be obscured or obstructed by any part of the vehicle or any attachment thereto or by the load carried.

4 The dimensions of a slow moving vehicle sign may be greater than the dimensions prescribed and illustrated in section 2 so long as each dimension is increased and, when increased, has the same relation to the other dimensions of the sign as the dimensions prescribed and illustrated have to each other.

5 A slow moving vehicle sign shall be deemed to meet the requirements of this Regulation if the sign is marked with the monogram of the Canadian Standards Association Testing Laboratories.

The above regulation would be applicable to roadside waste collection vehicles because they are generally travelling considerably slower than 40 kilometres per hour, or stopped in the roadway (either the travelled lane or shoulder), while carrying out the waste collection operation. They are, in fact, a slow moving vehicle.

Chapter 34, An Act to Amend the Motor Vehicle act, Assented to May 30, 1985 has sections that are relevant to domestic waste collection vehicles. The following sections are direct quotes:

PART V

LOAD CONFINEMENT REQUIREMENTS FOR SAND, CLEAR AGGREGATE, SALT, WASTE, SHREDDED SCRAP METAL OR OTHER LOOSELY PACKED BULK MATERIALS OR LIQUID MATERIALS

20 Where a vehicle or combination of vehicles transports on a highway a load of sand, clear aggregate, salt, waste, shredded scrap metal, or any mixture thereof, those loads shall be covered and confined in accordance with this Part.

21(1) A vehicle transporting firewood, Christmas trees, tree branches, moss, seaweed or other similar loosely packed bulk materials or transporting liquid or semi-liquid materials shall be constructed in such a manner as to prevent the contents thereof from dropping, sifting, leaking, or otherwise escaping from the vehicle.

Application of the above regulation to domestic waste collection vehicles should prevent any further complaints (as has been experienced by the New Brunswick Department of Transportation) regarding the loss of garbage off the uncovered trucks that are (or were) used in the collection of rural domestic waste.

Particular sections of the Motor Vehicle Act, Chapter M-17 are considered applicable to the safe operation of waste collection vehicles.

225(3) Flashing or revolving lights are prohibited on motor vehicles except in the following cases:

(a) an authorized emergency vehicle,

(b) a Department of Transportation vehicle,

(c) a school bus,

(d) a service vehicle,

(e) any vehicle as a means of indicating a right or left turn, and

(f) any vehicle equipped with an emergency flashing switch permitting the parking and tail lights to flash only when such vehicle is parked on the highway or any portion thereof due to an emergency or under circumstances beyond the control of the driver. 1978, c.D-11.2, s.26.

225(4) Where a service vehicle is equipped with a revolving or flashing light the light shall be amber in color.

As a utility vehicle operating at very slow speeds and frequently stopping in the travelled roadway, waste collection vehicles should be equipped with flashing or revolving lights that are cleary visible from all angles.

3.4 Recommended Safety Guidelines

3.4.1 Vehicle Signing, Lighting and Operation

Accidents between vehicles travelling in the same direction represents a large proportion of all traffic accidents. Past studies have shown that as the speed differential between two vehicles travelling in the same direction increases, the accident rate (and therefore risk) increases substantially. By its very nature the solid waste collection operation requires that the collection vehicle come to a complete stop, in the driving lane in many cases, and as a result is creating a high accident risk situation. The maximum speed differential results between the stopped collection vehicle and other vehicles operating on the road or street at or near the posted speed. In rural areas, this implies a potential speed differential of 80 or 90 kilometres per hour or more.

The driver of the overtaking vehicle has poor judgement of the leading vehicle's (collection vehicle's) speed. It is possible that much more poor judgement may result where a queue of passenger cars is following a slow-moving collection vehicle. Often during such occurrences, the minimum safe following distance is violated. To avoid or minimize the hazard, traffic must be warned to move safety and cautiously in the area of the collection vehicle. This may be achieved through proper advisory signing and warning lights and appropriate safety equipment and safety procedures for the collection crew.

In order to enhance safety, it is not essential that drivers of approaching vehicles slow down significantly. What is essential is that they be aware of a potential hazard and be ready to react to it and, when following or passing, use more appropriate and safe distances. The most appropriate warning devices to be used for collection vehicles are, it is suggested, those most effective in warning drivers of slow-moving vehicles. The standard vehicle signage in New Brunswick for slow-moving vehicles is the base-down equilateral triangle, fluorescent yellow-orange in colour with a dark red retro-reflective border, as previously presented. The effectiveness of this technique of warning motorists of a slow-moving or stopped collection vehicle will be evaluated below. In addition, the use of rotating beacons, four-way flashers, arrow boards and red flags will be reviewed.

Slow-Moving Vehicle Sign

Studies have been done in Australia and the United States to determine the effectiveness of the Slow-Moving Vehicle Sign. The sign was originally developed in Australia where they also incorporated yellow/amber flashing lights in each corner of the equilateral triangle. In the United States and Canada the

equilateral triangle is used without flashing lights, but with fluorescent and retro-reflective colouring, and is considered to be equally effective.

The basic requirement is that every motorist recognize this triangular sign (shape and colour) as a standardized method of increasing the visibility of the vehicle and identifying it as a slow-moving vehicle. The Motor Vehicle Act and Regulations in New Brunswick incorporate this as a standard regulated sign and is also identified as such in motor vehicle training manuals. Therefore, the driving public should be well educated and trained to recognize this particular sign.

Harkness and Stuckey of Ohio State University investigated the use of the base down triangle as a slow-moving vehicle emblem, in addition to other emblems of varying sizes and shapes, and found the triangle to be the easiest to recognize. Pfister of Michigan State University showed a reduction in slow-moving vehicle accidents after legislation was passed in Michigan requiring the use of the slow-moving vehicle triangular emblem.

Asper, in studies comparing the effectiveness of the red flag to that of the base down equilateral triangle as a warning of a slow moving vehicle ahead, found that the slow-moving vehicle emblem could be seen at significantly further distances. These results were found applicable for such demographic variables as sex, age and place of residence. This conclusion was that, with the slow-moving vehicle emblem and a vehicle operating speed of 80 kilometres per hour, the motorist would have an additional 82 metres of warning on level roadways. This is particularly relevant to rural areas where posted speeds are typically 70-80 kilometres per hour or greater, as compared to the typical 50 kilometres per hour in the urban areas.

Four-Way Flashers

Various studies have been done in the United States to evaluate the effectiveness of four-way flashers in warning drivers of a stopped or slow-moving vehicle. Using the four-way flashers helps to alert other drivers of a potentially hazardous situation. In other words, a solid waste collection vehicle with four-way flashers operating, while in the process of collecting domestic waste at the curbside, tells other drivers that this vehicle is not merely driving along the street, it is moving at a very slow speed or st.. ed. In conjunction with recognizing the vehicle as a domestic waste collection vehicle, drivers alert themselves to the fact that there must also be workmen in the immediate vicinity and will react accordingly. The safety of the crew and drivers is thus improved. Otherwise, drivers must use the workmen as the alerting medium--a very hazardous and undesirable situation.

The report "Evaluation of Techniques for Warning of Slow-Moving Vehicles Ahead" indicates, as the principle finding, that the use of standard four-way flashers is an effective device for reducing the hazards of the overtaking situation relative to reaction distance, speed reduction, and following characteristics.

Similar results are reported in the study "Safety Aspects of Using Vehicle Hazard Warning Lights." A summary of the findings are presented in this direct quote.

> "Initial Reaction Distance (IRD): An increase in initial reaction distance indicates that drivers of overtaking vehicles responded to the slow-moving vehicle with flashers at a greater distance than they did to a slow-moving vehicle without flashers.

Time to Collision (TTC): An increase in the time to collision measure indicates that drivers of the approaching vehicles slowed down earlier, so that the theoretical rear-end collision was less likely.

Distance at Maximum Deceleration (DMD): An increase in DMD indicates that the point of greatest deceleration occurs farther from the slow-moving vehicle, and that vehicles with activated flashers caused drivers of approaching vehicles to slow down farther from the slow-moving vehicle.

Passer Distance at Lane Change (PDLC): The drivers of passing vehicles changed lanes farther from the slow-moving vehicle. It is apparent that drivers were aware of the speed differential sooner and responded appropriately."

Lyles in his research work reported in 1982 essentially the same conclusions. He found that four-way flashers were the most effective device for decreasing the potential of a dangerous conflict when a faster moving vehicle overtakes a slow or stopped vehicle. Specific positive measures of improvement included the initial reaction distance, closing rate and minimum headways.

The overall conclusion is that four-way flashers are an effective device for reducing the hazardousness of the overtaking situation relative to the reaction distance, speed reduction and vehicle following characteristics. Therefore, activated four-way flashers on slow-moving/stopped collectin vehicles is an effective means for reducing accident potential when these vehicles are overtaken by faster moving vehicles.

Flashing Arrow Boards

The report "Effectiveness of Flashing Arrow Boards During Moving Maintenance Operations" was reviewed since the operation of domestic waste collection vehicles is somewhat similar to moving roadway maintenance operations. In both circumstances, slow or

stopped vehicles are creating a hazardous situation in the travelled lane in the same direction of travel. In addition, workmen are carrying out their duties in the travelled lane as well.

However, it would appear that, in general, the use of flashing arrow boards is not really appropriate for domestic waste collection vehicles. Arrow boards are more appropriate for a train of vehicles such as a highway maintenance striping crew confined to a certain area (or lane groupings such that a travelled lane is still available in the same direction as opposed to the typical collection vehicle which, during waste pickup, could be operating close to the shoulder, but during transit between pickups (households) could move well into the travelled lane, and when restricted by curbing (generally urban condition) is continuously in the travelled lanes. In addition, flashing arrow boards are really more appropriate for multi-lane facilities (which, in effect, indicates to the travelling public that they should make a lane change as opposed to a passing maneuver typically made on a two-lane rural road or urban street).

Rotating Beacon Lights/Flashers

As a service vehicle, domestic waste collection vehicles are required to have one yellow flashing light on the front of the vehicle. In the majority of cases, this would serve only as a warning device for oncoming traffic as opposed to traffic approaching from the rear. Previous discussion of the risk of a rear-end collision clearly indicates that this is a totally inadequate safety measure.

In terms of effectiveness, rotating beacons and flashers can be helpful in alerting the travelling public to a potentially dangerous situation. However, since for a fair number of utility vehicles including hydro and telephone service vehicles, maintenance vehicles, tow trucks, etc., the actual nature of the activity may not be clear to the travelling public. This would imply that rotating beacons, by themselves, are not sufficient warning. Certainly a rotating beacon/flasher should be provided at both the front and rear of the vehicle. They are more effective than four-way flashers for the initial warning, particularly where rolling terrain with varying grades are involved, under these circumstances the rotating beacons/flashers are much higher off the ground and therefore visible much sooner.

Red flags mounted on a vehicle perform much the same function as rotating beacons and flashers, but again they are not sufficient, by themselves, in warning the drivers of other vehicles of the nature of the waste collection operation.

Roadside Warning Signings

Roadside warning signs are always used when road maintenance or construction crews are active in the travelled lanes. Generally speaking, these activities are confined to a particular length of highway or street. As such, traffic control and warning are easier to manage than is the case with domestic waste collection vehicles which, although stopping frequently, are on the move continuously.

Lanman, in the report "Evaluation of Techniques for Warning of Slow-Moving Vehicles Ahead", indicates that roadside signs are relatively ineffective as warning devices for the overtaking

situation. The approaching motorists who saw the signs that caused the immediate reaction did not generally behave any differently at the point of overtaking from those who saw no sign.

Because of their relative ineffectiveness, roadside warning signs are not recommended, in general, as part of the safety procedures for the domestic waste collection system. They would add considerably to the effort of waste collection, add inefficiency to the operation and actually increase the time the collection vehicle and workmen would be exposed to existing traffic hazards.

Vehicle Operation and Safety Recommendations

From the previous discussion it can be seen that the domestic waste collection operation is potentially hazardous and with the relatively low speed and frequent stops, it is imperative that other drivers, particularly those approaching from the rear, have the earliest and most effective warning.

The safety recommendations are:

1. Rotating beacons/flashers be provided both at the front and back of the solid waste collectin vehicle;

2. While in the actual process of collecting domestic waste, the four-way flashers be operated as well (since they were found to be one of the most effective way of alerting drivers to a slow-moving or stopped vehicle);

3. The slow-moving vehicle sign be attached to the vehicle in accordance with Regulation 84-98 under the New Brunswick Motor Vehicle Act.

In the actual operation of the vehicle, all the rules of the road according to the Motor Vehicle Act and related regulations be adhered to and refrain from using the vehicle for collection on the wrong side of the road or zig-zagging from one side of the road to the other. Collection should be made in the direction of the traffic flow. All loads of domestic waste should be adequately covered to prevent unlawful spillage or loss of load.

3.4.2 Personnel Operational and Safety Requirements

Domestic waste collection vehicles and the associated activity related to the roadside collection process actually has two basic hazards involved. One is the slow-moving or stopped vehicle itself, but the other is the activity related to the crew members themselves. The workmen, as part of their duty, must be behind the collection vehicle to put the collected waste into the truck; this inherently puts these workmen in a high risk, hazardous position. Therefore, their dress, mannerism and activities while carrying out their duties must be carefully planned to maximize their safety.

As previously discussed, it is felt that the workmen should wear safety hats and safety footwear because they are working with mobile equipment (waste collection vehicles) and are loading the collection trucks with varied types of waste; the majority of the time it would be the normal domestic garbage, but during cleanup periods it could vary considerably in size and weight. The safety hats not only protect the workmen from potential head injuries but help to alert other drivers to their presence and nature of their activity. Although not specifically required by any Act or Regulation to date, it is recommended that the collection personnel all be required to wear a (fluorescent red or orange) safety jacket to identify them as workmen carrying out their duties in the roadway. It is stressed that the intent

is not to use the safety dress of the workmen to alert drivers to the potential hazard of the waste collection operation; the safety features of the collection vehicle should clearly serve this purpose. It is critical, however, that each and every workman be identified by the drivers of the other vehicles.

Safety equipment is not meant to free the workman of any responsibility for watching for traffic. Their own alertness is critical and responsible actions are required at all times. By the very nature of their duties they have to turn their backs to the traffic while putting waste into the collection truck. However, once the garbage is in the truck they should observe the traffic situation before making any sudden moves. Specifically, they should not be crossing to the other side of the road to pick up garbage. Domestic waste collection should be carried out on one side of the road at a time and in the same direction as the traffic flow.

On larger operations, in particular, it is recommended that safety policies be defined by the collection contractor. This would include establishing a safety committee and training programs in safety practices. For smaller contractors, the general safety guidelines and policies developed by the Department of Municipal Affairs and Environment could be used. All contractors would obviously have to adhere to any existing and future safety regulations provided for under the Motor Vehicle Act and Occupational Health and Safety Act or any other Provincial Acts and Regulations.

3.4.3 Road/Street Geometric Considerations

The highway and street geometries and posted speed can play a critical role in the safety of domestic waste collection. Even if the recommended safety practices were to be put in place for

the waste collection vehicle and personnel, there still remains particular hazard that are characteristic of the roadway. They require particular attention and consideration by the collection crew.

Sharp curves pose a particular hazard, most notably in the rural areas of the province. Under such conditions collection vehicles should be operated on, or as close as possible to, the shoulder. If at all practical, the collection vehicle should remain at the beginning of the curve while the collection crew carry the solid waste to the collection vehicles. In very dangerous situations, warning signs should be placed at the beginning of the sharp curve(s). This may be the only safe alternative where there is a limited shoulder combined with a sharp, blind curve. This is particularly hazardous if the posted speed is 70 to 80 kilometres per hour or more. Blind knolls are really sharp vertical curves posing much of the same hazard as the aformentioned sharp horizontal curves. In addition, they may have relatively steep grades associated with them. The aforementioned safety practices should again be applied in these circumstances. In addition, one of the crew may have to act as flagman in these hazardous areas of the route.

Winter conditions pose other types of hazards. Because domestic waste collection vehicles are operating at very slow speeds and stop frequently on the roadway, they should not be operated on icy, slippery roads, and particularly where sharp curves and steep grades are involved. The collection operation should be delayed until the road is salted and/or sanded. This will probably affect the collection contractor's schedule, but safety considerations must come first.

Generally speaking, highways and roads with the higher speeds have the better geometrics (lower grades, smoother curves, better sight distances) and a relatively good, wide shoulder. The waste collection operation on high speed highways and roads should be carried out on the shoulder. The majority of highways in New Brunswick are two-lane, bi-directional roadways so that there is no lane free for a lane change if the waste collection vehicle occupies the travelled lane. This forces other traffic to make a passing maneuver, perhaps where a solid line exists. Locations where the collection vehicle must operate in the travelled lane may require that one of the crew temporarily act as a flagman until operations can continue on the shoulder.

Safe operations must be maintained at intersections and railway crossings. A collection vehicle does not have special privileges and therefore must obey the rules (law) of the road. All collection of waste must be completed prior to both the collection vehicle and crew passing through an intersection. The vehicle should not stop in the intersection and the crew should not be carrying garbage through the intersection or be running back through the intersection to collect more garbage. At railway crossings the vehicle should not be stopped near or on the tracks while the workmen collect and dump the garbage into the truck.

It should be noted that the responsibility for safe operations lies with both the contractor and the personnel he has collecting the domestic waste. The size of the operation should not be relevant to the degree of the safety required. Small open trucking operations should follow the same safety practices as larger, more compact trucking operations.

3.4.4 Off-Highway Considerations

Off-highway waste collection operations are as important from the safety perspective as are road and street collection practices. There may be the attitude that once they leave the public road or street the collection crew can relax their safety procedures. However, in some respects there are more variables with which the crew must contend.

Container site operations is one area where the waste collection vehicle must be operated safely as on the highway, because the public are free to use the site at any time. Therefore, public and private vehicles may be at the container site at the same time. Alertness to the surrounding vehicles and persons at the sight must be maintained. The collection vehicle is often operated in reverse and the collection crew are carrying out a number of duties, all of which should be coordinated to ensure the safety of the crew and public. Operation of safety equipment should be maintained during these operations. Potentially some smaller container sites could be located in or near service stations, convenience stores or similar areas where the amount of other vehicular and pedestrian activity could be considerable. It is the responsibility of the collection crew to ensure that they carry out their duties in a safe manner at all times. The crew and driver should be courteous and respectful of other vehicles and drivers, and follow the rules (law) of the road while off the road and when reentering the main traffic stream.

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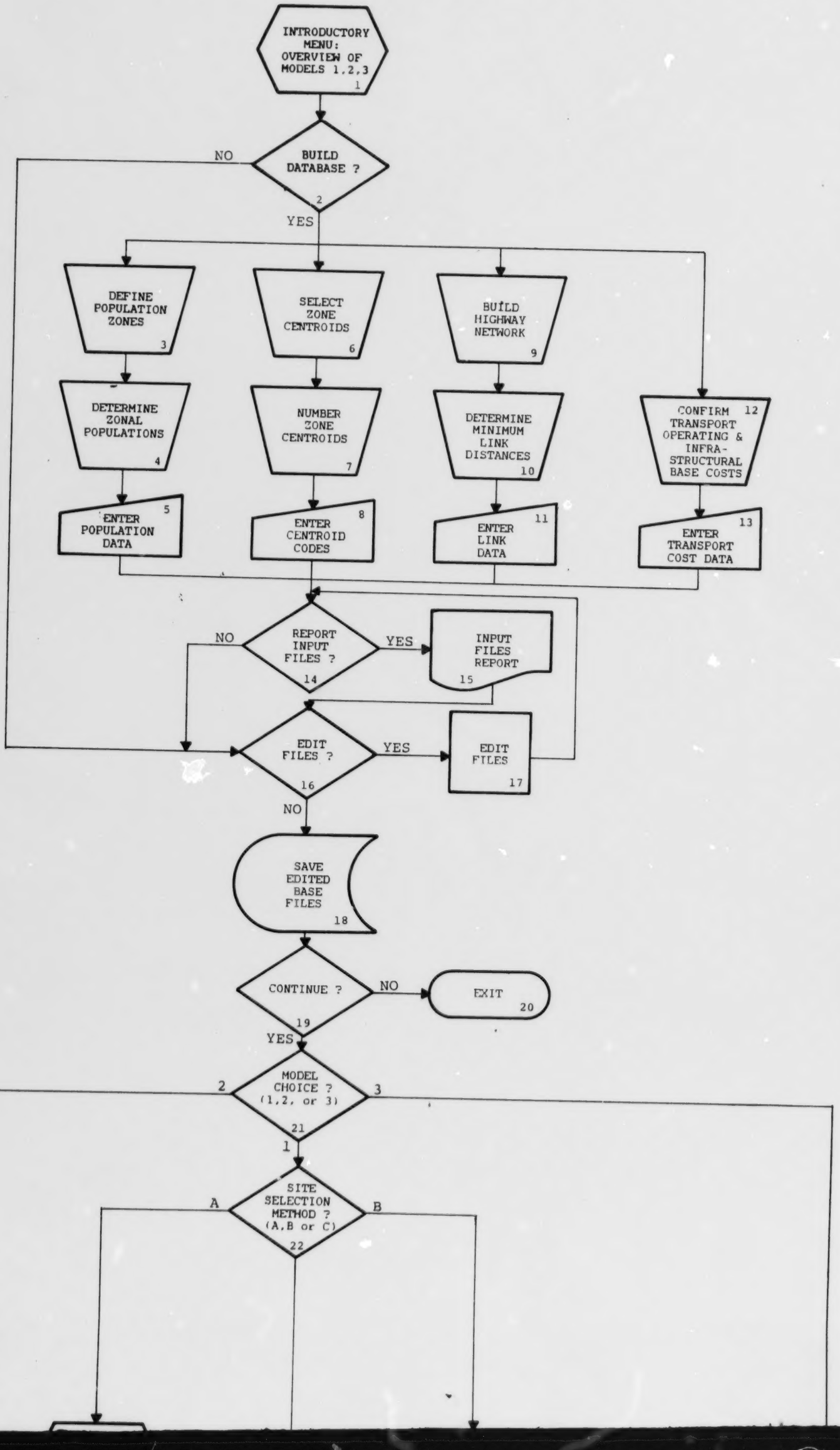
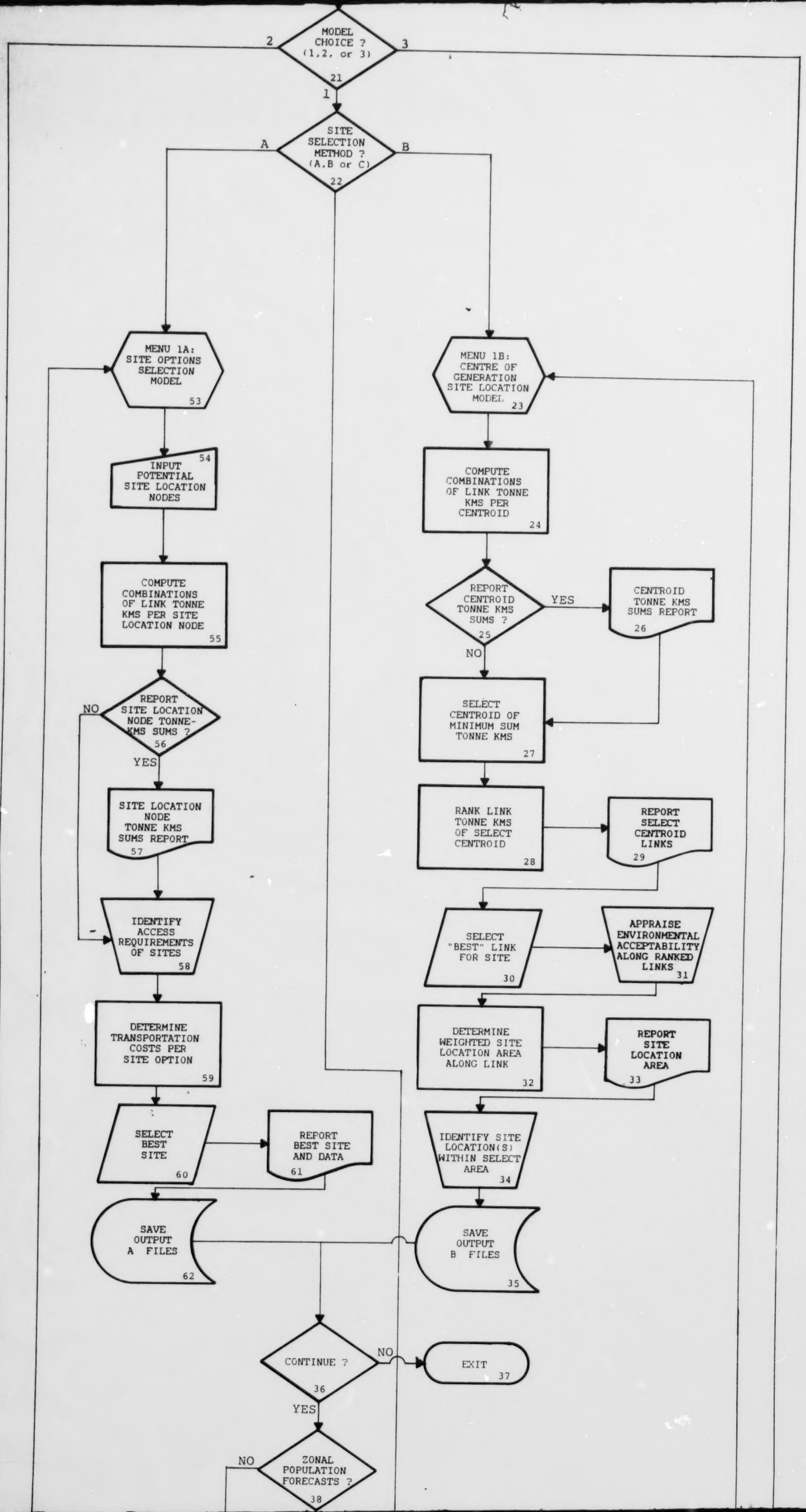
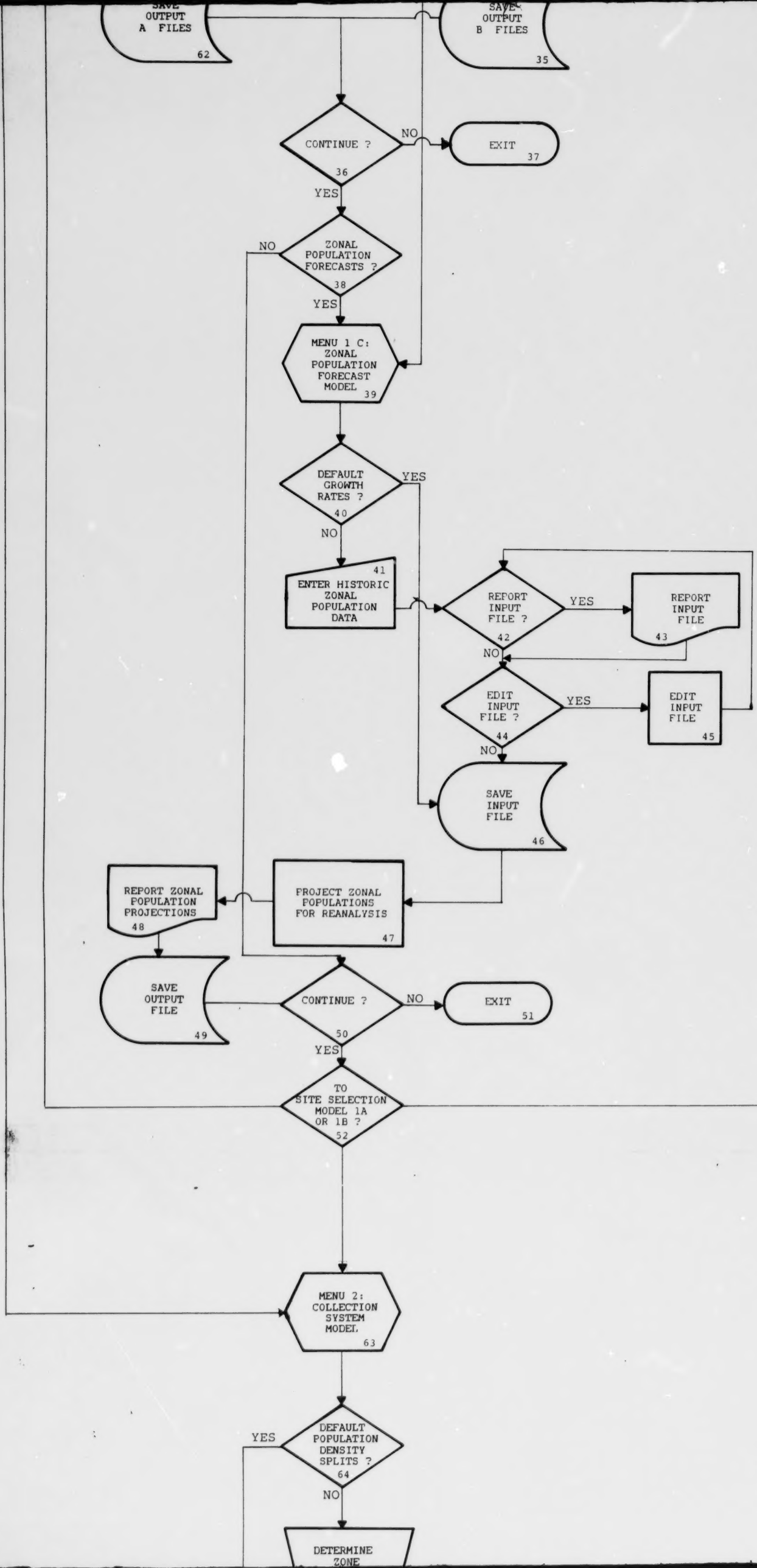
APPENDIX I

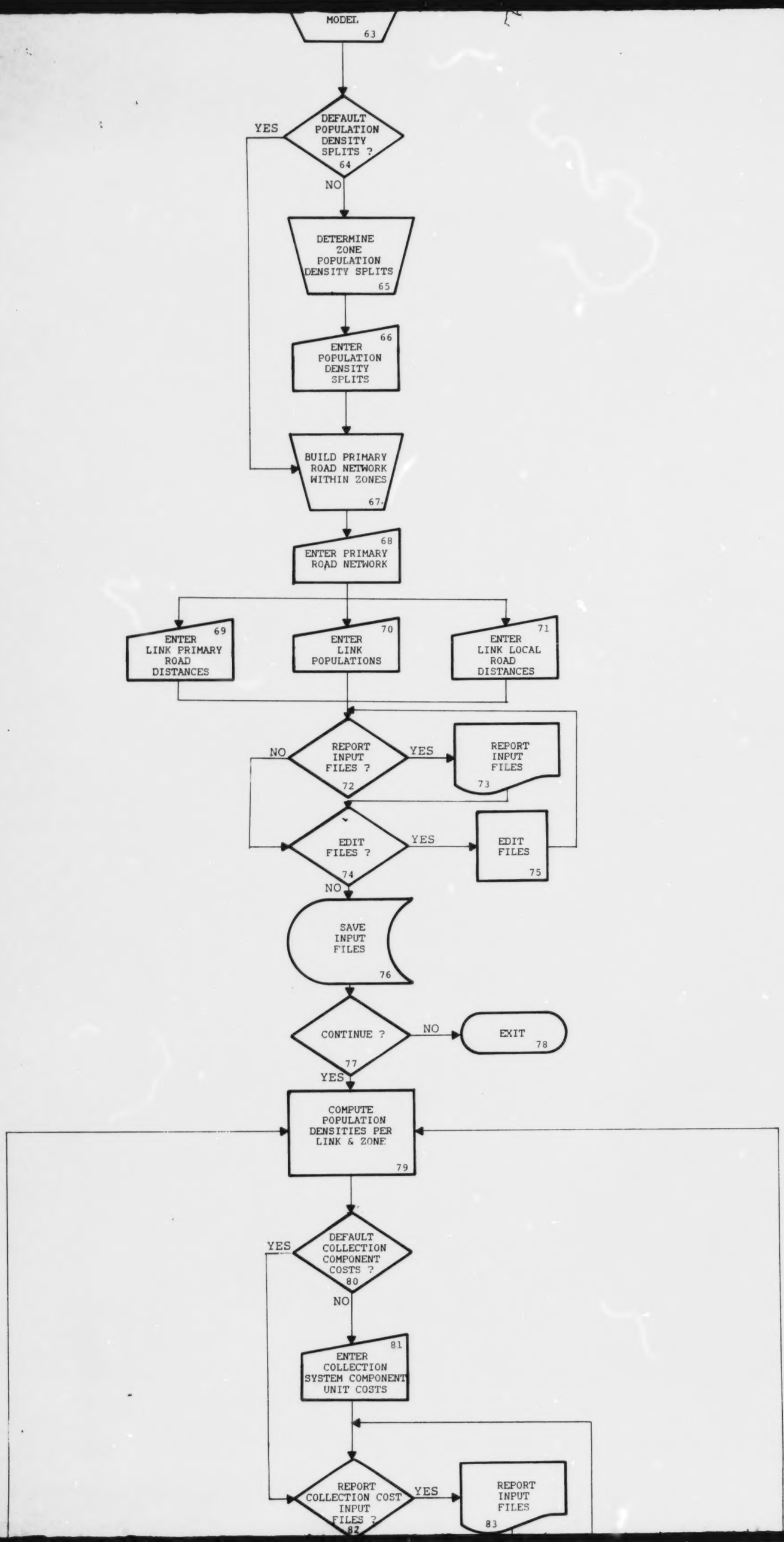
FLOW CHART OF THE SWAT COMPUTER PROGRAM MODEL

SOLID WASTE TRANSPORTATION MODEL




MODEL CHOICE ? (1,2, or 3)
21
2
3
1
SITE SELECTION METHOD ? (A,B or C)
22
A
B
MENU 1A: SITE OPTIONS SELECTION MODEL
53
INPUT POTENTIAL SITE LOCATION NODES
54
COMPUTE COMBINATIONS OF LINK TONNE KMS PER SITE LOCATION NODE
55
REPORT SITE LOCATION NODE TONNE-KMS SUMS ?
56
NO
YES
SITE LOCATION NODE TONNE KMS SUMS REPORT
57
IDENTIFY ACCESS REQUIREMENTS OF SITES
58
DETERMINE TRANSPORTATION COSTS PER SITE OPTION
59
SELECT BEST SITE
60
REPORT BEST SITE AND DATA
61
SAVE OUTPUT A FILES
62
MENU 1B: CENTRE OF GENERATION SITE LOCATION MODEL
23
COMPUTE COMBINATIONS OF LINK TONNE KMS PER CENTROID
24
REPORT CENTROID TONNE KMS SUMS ?
25
YES
NO
CENTROID TONNE KMS SUMS REPORT
26
SELECT CENTROID OF MINIMUM SUM TONNE KMS
27
RANK LINK TONNE KMS OF SELECT CENTROID
28
REPORT SELECT CENTROID LINKS
29
SELECT "BEST" LINK FOR SITE
30
APPRAISE ENVIRONMENTAL ACCEPTABILITY ALONG RANKED LINKS
31
DETERMINE WEIGHTED SITE LOCATION AREA ALONG LINK
32
REPORT SITE LOCATION AREA
33
IDENTIFY SITE LOCATION(S) WITHIN SELECT AREA
34
SAVE OUTPUT B FILES
35
CONTINUE ?
36
NO
YES
EXIT
37
ZONAL POPULATION FORECASTS ?
38
NO


SAVE OUTPUT A FILES
62
SAVE OUTPUT B FILES
35
CONTINUE ?
36
NO
EXIT
37
YES
ZONAL POPULATION FORECASTS ?
38
NO
YES
MENU 1 C: ZONAL POPULATION FORECAST MODEL
39
DEFAULT GROWTH RATES ?
40
YES
NO
ENTER HISTORIC ZONAL POPULATION DATA
41
REPORT INPUT FILE ?
42
YES
REPORT INPUT FILE
43
NO
EDIT INPUT FILE ?
44
YES
EDIT INPUT FILE
45
NO
SAVE INPUT FILE
46
PROJECT ZONAL POPULATIONS FOR REANALYSIS
47
REPORT ZONAL POPULATION PROJECTIONS
48
SAVE OUTPUT FILE
49
CONTINUE ?
50
NO
EXIT
51
YES
TO SITE SELECTION MODEL 1A OR 1B ?
52
MENU 2: COLLECTION SYSTEM MODEL
63
DEFAULT POPULATION DENSITY SPLITS ?
64
YES
NO
DETERMINE ZONE


MODEL
63
DEFAULT POPULATION DENSITY SPLITS ?
64
YES
NO
DETERMINE ZONE POPULATION DENSITY SPLITS
65
ENTER POPULATION DENSITY SPLITS
66
BUILD PRIMARY ROAD NETWORK WITHIN ZONES
67
ENTER PRIMARY ROAD NETWORK
68
ENTER LINK PRIMARY ROAD DISTANCES
69
ENTER LINK POPULATIONS
70
ENTER LINK LOCAL ROAD DISTANCES
71
REPORT INPUT FILES ?
72
NO
YES
REPORT INPUT FILES
73
EDIT FILES ?
74
YES
EDIT FILES
75
NO
SAVE INPUT FILES
76
CONTINUE ?
77
NO
EXIT
78
YES
COMPUTE POPULATION DENSITIES PER LINK & ZONE
79
DEFAULT COLLECTION COMPONENT COSTS ?
80
YES
NO
ENTER COLLECTION SYSTEM COMPONENT UNIT COSTS
81
REPORT COLLECTION COST INPUT FILES ?
82
YES
REPORT INPUT FILES
83

REPORT INPUT FILES 83

EDIT INPUT FILES 85

COMPONENT COSTS ? 80

NO

81 ENTER COLLECTION SYSTEM COMPONENT UNIT COSTS

YES

REPORT COLLECTION COST INPUT FILES ? 82

NO

YES

EDIT INPUT FILES ? 84

NO

SAVE INPUT FILES 86

NO

CONTINUE ? 87

YES

EXIT 88

USER DELIVERY TO SOLID WASTE CONTAINER OPTION 91

DETERMINE NUMBER OF CONTAINER SITES REQUIRED 98

DETERMINE CONTAINER SITE LOCATIONS 99

100 ENTER CONTAINER SITE NODES

YES

REPORT INPUT FILES ? 101

NO

REPORT INPUT FILES 102

YES

EDIT INPUT FILES ? 103

NO

EDIT INPUT FILES 104

SAVE INPUT FILES 105

NO

CONTINUE ? 106

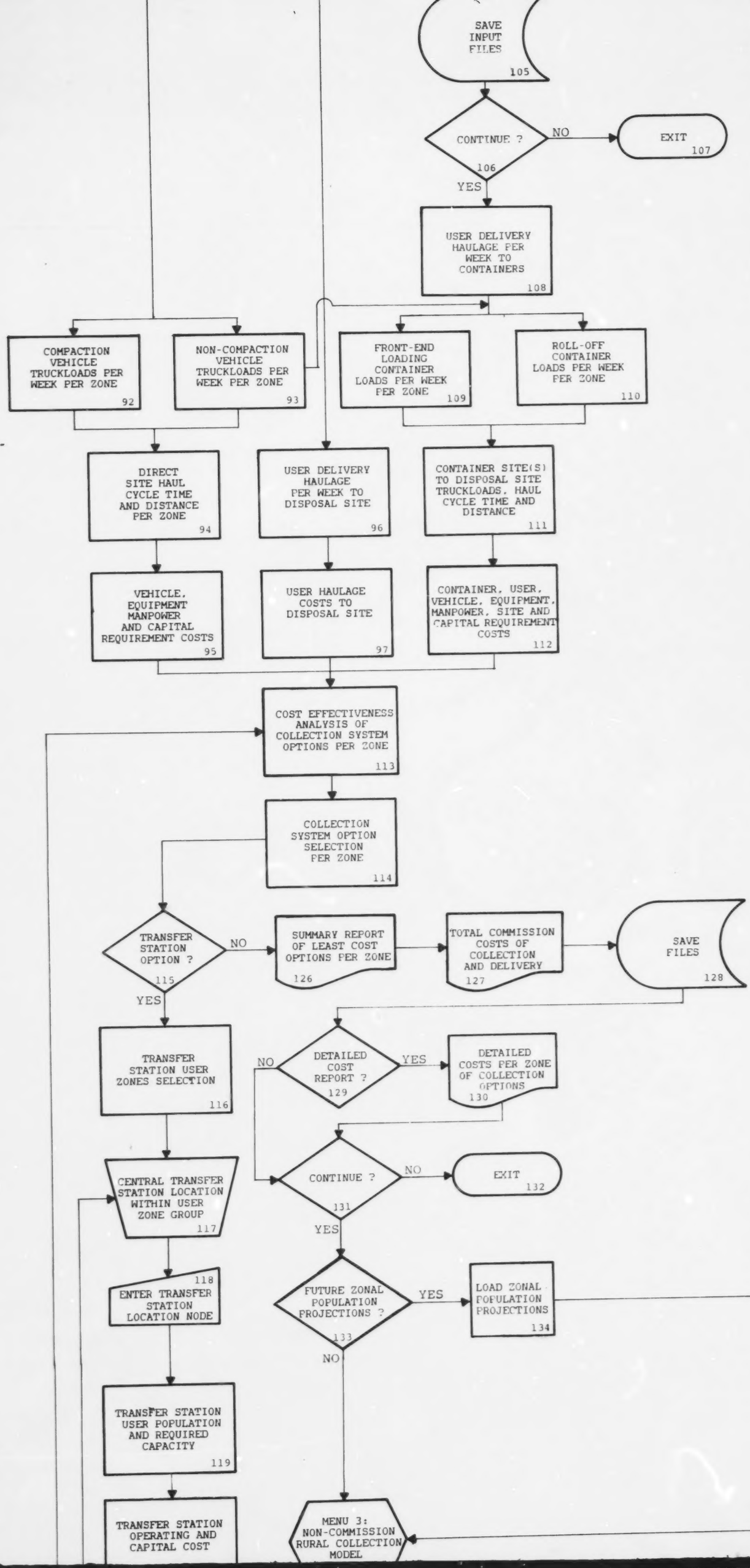
YES

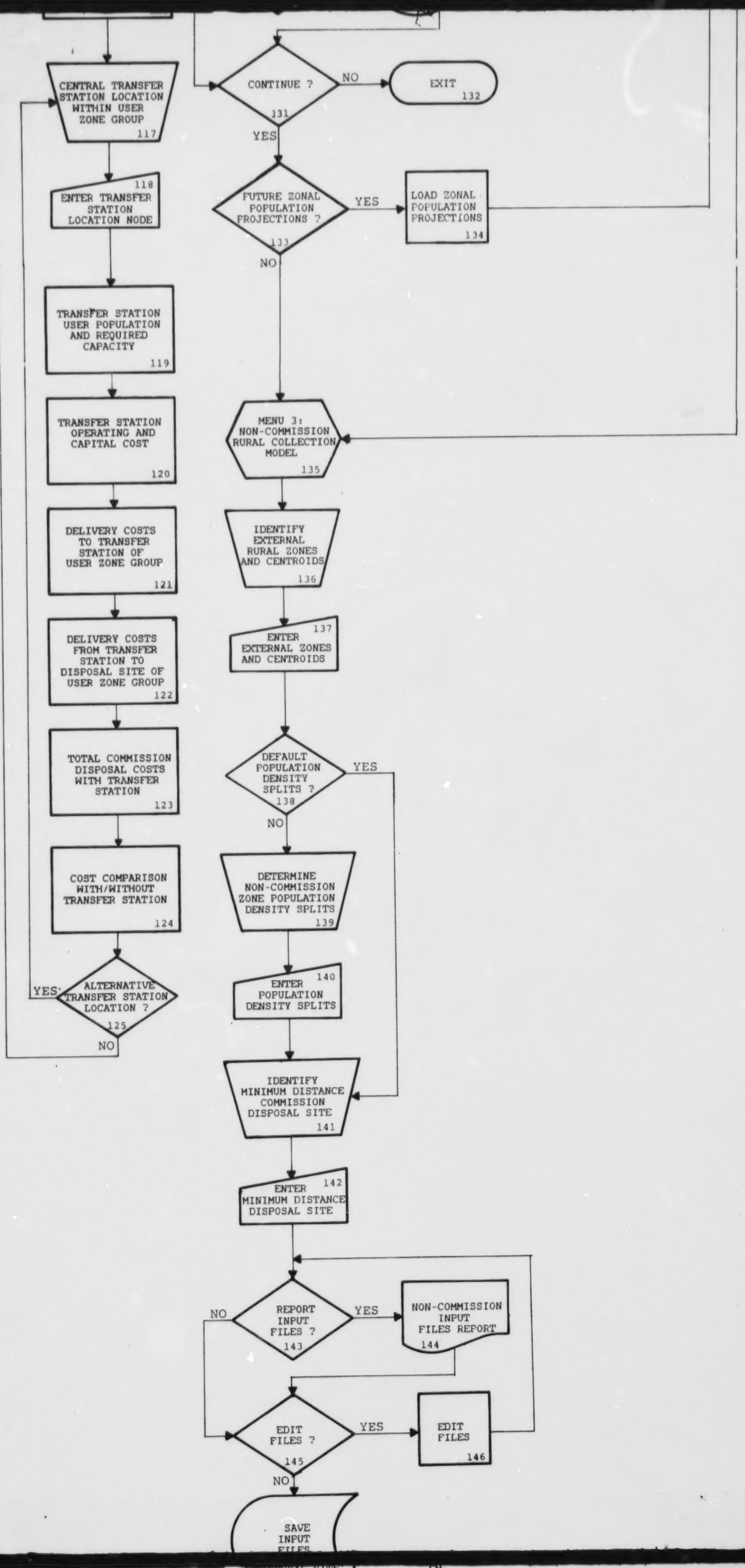
EXIT 107

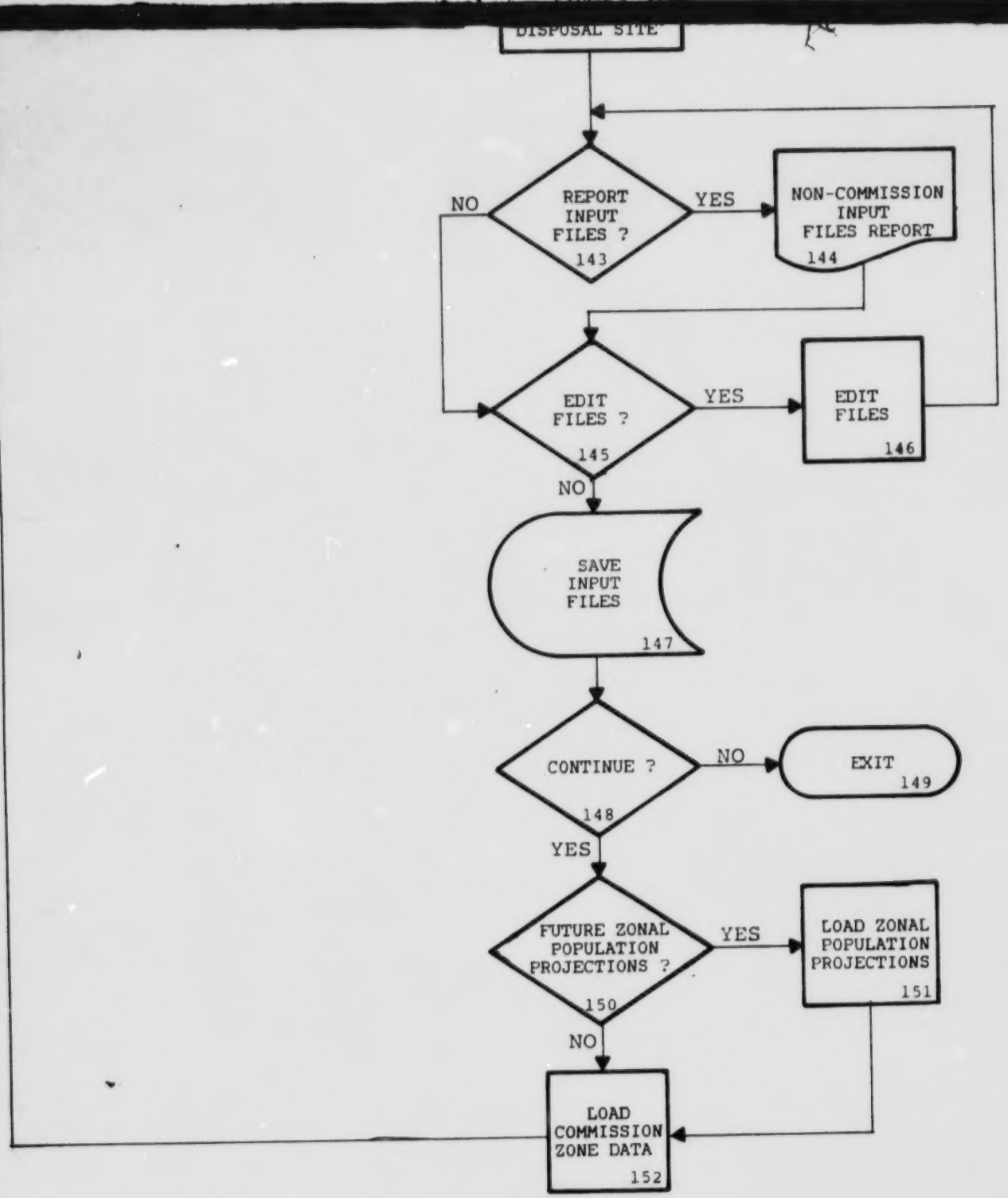
USER DELIVERY HAULAGE PER WEEK TO CONTAINERS 108

USER DELIVERY TO DISPOSAL SITE OPTION 90

ROADSIDE SOLID WASTE COLLECTION OPTION 89


SAVE INPUT FILES
105
CONTINUE ?
106
NO
EXIT
107
YES
USER DELIVERY HAULAGE PER WEEK TO CONTAINERS
108
COMPACTION VEHICLE TRUCKLOADS PER WEEK PER ZONE
92
NON-COMPACTION VEHICLE TRUCKLOADS PER WEEK PER ZONE
93
FRONT-END LOADING CONTAINER LOADS PER WEEK PER ZONE
109
ROLL-OFF CONTAINER LOADS PER WEEK PER ZONE
110
DIRECT SITE HAUL CYCLE TIME AND DISTANCE PER ZONE
94
USER DELIVERY HAULAGE PER WEEK TO DISPOSAL SITE
96
CONTAINER SITE(S) TO DISPOSAL SITE TRUCKLOADS, HAUL CYCLE TIME AND DISTANCE
111
VEHICLE, EQUIPMENT MANPOWER AND CAPITAL REQUIREMENT COSTS
95
USER HAULAGE COSTS TO DISPOSAL SITE
97
CONTAINER, USER, VEHICLE, EQUIPMENT, MANPOWER, SITE AND CAPITAL REQUIREMENT COSTS
112
COST EFFECTIVENESS ANALYSIS OF COLLECTION SYSTEM OPTIONS PER ZONE
113
COLLECTION SYSTEM OPTION SELECTION PER ZONE
114
TRANSFER STATION OPTION ?
115
NO
SUMMARY REPORT OF LEAST COST OPTIONS PER ZONE
126
TOTAL COMMISSION COSTS OF COLLECTION AND DELIVERY
127
SAVE FILES
128
YES
TRANSFER STATION USER ZONES SELECTION
116
DETAILED COST REPORT ?
129
NO
YES
DETAILED COSTS PER ZONE OF COLLECTION OPTIONS
130
CENTRAL TRANSFER STATION LOCATION WITHIN USER ZONE GROUP
117
CONTINUE ?
131
NO
EXIT
132
YES
118
ENTER TRANSFER STATION LOCATION NODE
FUTURE ZONAL POPULATION PROJECTIONS ?
133
YES
LOAD ZONAL POPULATION PROJECTIONS
134
NO
TRANSFER STATION USER POPULATION AND REQUIRED CAPACITY
119
TRANSFER STATION OPERATING AND CAPITAL COST
MENU 3: NON-COMMISSION RURAL COLLECTION MODEL


CENTRAL TRANSFER STATION LOCATION WITHIN USER ZONE GROUP
117
ENTER TRANSFER STATION LOCATION NODE
118
TRANSFER STATION USER POPULATION AND REQUIRED CAPACITY
119
TRANSFER STATION OPERATING AND CAPITAL COST
120
DELIVERY COSTS TO TRANSFER STATION OF USER ZONE GROUP
121
DELIVERY COSTS FROM TRANSFER STATION TO DISPOSAL SITE OF USER ZONE GROUP
122
TOTAL COMMISSION DISPOSAL COSTS WITH TRANSFER STATION
123
COST COMPARISON WITH/WITHOUT TRANSFER STATION
124
ALTERNATIVE TRANSFER STATION LOCATION ?
125
YES
NO
CONTINUE ?
131
NO
EXIT
132
YES
FUTURE ZONAL POPULATION PROJECTIONS ?
133
YES
LOAD ZONAL POPULATION PROJECTIONS
134
NO
MENU 3: NON-COMMISSION RURAL COLLECTION MODEL
135
IDENTIFY EXTERNAL RURAL ZONES AND CENTROIDS
136
ENTER EXTERNAL ZONES AND CENTROIDS
137
DEFAULT POPULATION DENSITY SPLITS ?
138
YES
NO
DETERMINE NON-COMMISSION ZONE POPULATION DENSITY SPLITS
139
ENTER POPULATION DENSITY SPLITS
140
IDENTIFY MINIMUM DISTANCE COMMISSION DISPOSAL SITE
141
ENTER MINIMUM DISTANCE DISPOSAL SITE
142
REPORT INPUT FILES ?
143
NO
YES
NON-COMMISSION INPUT FILES REPORT
144
EDIT FILES ?
145
YES
NO
EDIT FILES
146
SAVE INPUT FILES


DISPOSAL SITE
REPORT INPUT FILES ?
143
NO
YES
NON-COMMISSION INPUT FILES REPORT
144
EDIT FILES ?
145
YES
EDIT FILES
146
NO
SAVE INPUT FILES
147
CONTINUE ?
148
NO
EXIT
149
YES
FUTURE ZONAL POPULATION PROJECTIONS ?
150
YES
LOAD ZONAL POPULATION PROJECTIONS
151
NO
LOAD COMMISSION ZONE DATA
152

APPENDIX II

SAMPLE COMPUTER RUN
SWAT MODEL

SOLID WASTE TRANSPORTATION MODEL

BY
ADI LIMITED

FOR
ENVIRONMENTAL PROTECTION BRANCH

NEW BRUNSWICK
DEPARTMENT OF MUNICIPAL AFFAIRS
AND ENVIRONMENT

*** type "ENTER" to proceed ***

```
ENTER:          1 TO RUN SWATMODEL
                2 TO VIEW FILE DIRECTORY
                3 TO ACCESS EXISTING REPORTS
                4 TO COPY A FILE
                5 TO ERASE A FILE
                6 TO EXIT

                     *** USE ONLY CHARACTERS WHEN ENTERING FILE NAMES ***

:
        1
SWATMODEL
PRELIM
```

```
WHAT IS THE NAME OF THIS RUN ? (use up to seven characters):
SAMPLE
DO YOU WANT TO USE EXISTING DATABASES ? (Y or N)
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
```

```
                    SOLID WASTE TRANSPORTATION MODEL
          21          22          23          24          25          26
 1 ********************************************************************************
 2 *                                                                              *
 3 *                                                                              *
 4 *                                                                              *
 5 *                              SWAT MODEL                                      *
 6 *                                                                              *
 7 *                                 BY                                           *
 8 *                              ADI LIMITED                                     *
 9 *                                                                              *
10 *                                                                              *
11 *                                                                              *
12 *                                FOR                                           *
13 *                     ENVIRONMENTAL PROTECTION BRANCH                          *
14 *                                                                              *
15 *                              NEW BRUNSWICK                                   *
16 *                     DEPARTMENT OF MUNICIPAL AFFAIRS                          *
17 *                             AND ENVIRONMENT                                  *
18 *                                                                              *
19 *                                  *** PRESS CRTL X TO PROCEED ***             *
20 ********************************************************************************

Browsing; 26484 (Help: Ctrl H)

('ASF F=2 SWATX' SPEDIT 'ASF F=2 SWATIN') session pending...




DO YOU WANT A PROCEDURAL DESCRIPTION? (Y OR N)
N
     ENTER: 0 TO BUILD DATABASE
            1 TO USE MODEL 1
            2 TO USE MODEL 2/3
            3 TO EXIT
:
      0
```

```
WHICH DATABASE DO YOU WANT TO BUILD/EDIT ?
ENTER: 1 FOR ZONE, POPULATION AND HAULAGE COST
       2 FOR LINK DATA
       3 FOR POTENTIAL SITE LOCATIONS
       4 FOR SITE ACCESS REQUIREMENTS
       5 TO RETURN TO PREVIOUS MENU
:
     1
                    SOLID WASTE TRANSPORTATION MODEL
              1          2          3          4          5          6
    1
    2                              DATABASE #1
    3
    4                 POPULATION, ZONE AND HAULAGE COST INPUT DATA
    5                 ---------------------------------------------
    6
    7
    8
    9
   10                POPULATION BASE YEAR:          1986
   11          AVERAGE ANNUAL INFLATION RATE:          5 %
   12                      NUMBER OF ZONES:          0
   13
   14             SOLID WASTE PER CAPITA DAY:          1.36 kg
   15              AVERAGE LINE HAUL PAYLOAD:          4 te
   16            AVERAGE HAULAGE COST PER KM.:         1.67 $
   17
   18
   19                ZONES      POPULATION  te/DAY      te/WK       te/YR
   20                -----      ----------  ------      -----       -----
NWCELL 11 4 &                                          *** PRESS CTRL R ***
Browsing; 26484 (Help: Ctrl H)



                    SOLID WASTE TRANSPORTATION MODEL
              1          2          3          4          5          6
   11          AVERAGE ANNUAL INFLATION RATE:          5 %
   12                      NUMBER OF ZONES:          5
   13
   14             SOLID WASTE PER CAPITA DAY:          1.36 kg
   15              AVERAGE LINE HAUL PAYLOAD:          4 te
   16            AVERAGE HAULAGE COST PER KM.:         1.67 $
   17
   18
   19                ZONES      POPULATION  te/DAY      te/WK       te/YR
   20                -----      ----------  ------      -----       -----
   21
   22
   23
   24
   25
   26
   27
   28
   29
   30
NWCELL 19 2 &                                          *** PRESS CTRL R ***
Browsing; 26484 (Help: Ctrl H)
```

```
                    SOLID WASTE TRANSPORTATION MODEL
          1         2         3         4         5         6
    11  AVERAGE ANNUAL INFLATION RATE:      5 %
    12            NUMBER OF ZONES:          5
    13
    14    SOLID WASTE PER CAPITA DAY:     1.36 kg
    15     AVERAGE LINE HAUL PAYLOAD:        4 te
    16   AVERAGE HAULAGE COST PER KM.:     1.67 $
    17
    18
    19        ZONES     POPULATION  te/DAY     te/WK      te/YR
    20        -----     ----------  ------     -----      -----
    21
    22
    23
    24
    25
    26
    27
    28
    29
    30
sA&                                  *** PRESS CTRL R TO PRODUCE ZONE #'s ***
Browsing; 26484 (Help: Ctrl H)
```

```
                    SOLID WASTE TRANSPORTATION MODEL
          1         2         3         4         5         6
    19        ZONES     POPULATION  te/DAY     te/WK      te/YR
    20        -----     ----------  ------     -----      -----
    21              1
    22              2
    23              3
    24              4
    25              5
    26
    27
    28
    29
    30
    31
    32
    33
    34
    35
    36
    37
    38
sB&                                  *** PRESS CRTL R THEN '' KEY TWICE ***
Browsing; 26484 (Help: Ctrl H)
```

SOLID WASTE TRANSPORTATION MODEL

	1	2	3	4	5	6
19		ZONES	POPULATION	te/DAY	te/WK	te/YR
20		-----	----------	------	-----	-----
21		1	1036			
22		2	2886			
23		3	646			
24		4	752			
25		5	1023			
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						

sC NWCELL 19 8& *** PRESS CRTL R **
Browsing; 26484 (Help: Ctrl H)

SOLID WASTE TRANSPORTATION MODEL

	3	4	5	6	7	8
19	POPULATION	te/DAY	te/WK	te/YR	TRIPS/WK	TRIPS/YEAR
20	----------	------	-----	-----	--------	---------
21	1036	1.40896	9.86272	514.27	3	156
22	2886	3.92496	27.4747	1432.61	7	364
23	646	0.87856	6.14992	320.674	2	104
24	752	1.02272	7.15904	373.293	2	104
25	1023	1.39128	9.73896	507.817	3	156
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						

& *** THIS DATABASE IS COMPLETE - PRESS CRTL E TO PROCEED ***
Browsing; 26484 (Help: Ctrl H)

SOLID WASTE TRANSPORTATION MODEL

```
          36        37        38        39        40        41
     1 ****************************************************************************
     2 *                                                                          *
     3 *                                                                          *
     4 *                                                                          *
     5 *                                                                          *
     6 *                                                                          *
     7 *                                                                          *
     8 *                                                                          *
     9 *                *** PLEASE PRESS CTRL X TO CONTINUE ***                   *
    10 *                                                                          *
    11 *                                                                          *
    12 *                                                                          *
    13 *                                                                          *
    14 *                                                                          *
    15 *                                                                          *
    16 *                                                                          *
    17 *                                                                          *
    18 *                                                                          *
    19 *                                                                          *
    20 ****************************************************************************
```

Browsing; 26484 (Help: Ctrl H)

DO YOU WANT TO CREATE A REPORT FOR DATABASE #1 ? (Y or N)
Y
REPORTS
1988/1/21 9:22

A REPORT NAMED SAMPLE HAS BEEN CREATED

DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX

```
WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE

DATE: 1988/1/21 9:22

DATABASE #1: POPULATION, ZONE, AND HAULAGE COST DATA

POPULATION BASE YEAR:	1986
AVERAGE ANNUAL INFLATION RATE:	5 %
NUMBER OF ZONES:	5
SOLID WASTE PER CAPITA DAY:	1.36 kg
AVERAGE LINE HAUL PAYLOAD:	4 te
AVERAGE HAULAGE COST PER KM.:	1.67 $

ZONES	POPULATION	te/DAY	te/WK	te/YR	TRIPS/WK	TRIPS/YEAR
1	1036	1.40896	9.86272	514.27	3	156
2	2886	3.92496	27.4747	1432.61	7	364
3	646	0.87856	6.14992	320.674	2	104
4	752	1.02272	7.15904	373.293	2	104
5	1023	1.39128	9.73896	507.817	3	156

***HIT ANY KEY TO PROCEED ***

DO YOU WANT TO CONTINUE EDITING DATABASES ? (Y or N)
Y

WHICH DATABASE DO YOU WANT TO BUILD/EDIT ?
ENTER: 1 FOR ZONE, POPULATION AND HAULAGE COST
2 FOR LINK DATA
3 FOR POTENTIAL SITE LOCATIONS
4 FOR SITE ACCESS REQUIREMENTS
5 TO RETURN TO PREVIOUS MENU
:
2

SOLID WASTE TRANSPORTATION MODEL

DATABASE #2

LINK DATA FILE

CENTROID LINKS		DISTANCE	DIR. LINK ?
ORIGIN	DEST	KMS	(1=Y 0=N)

NWCELL 9 19&
Browsing; 26484 (Help: Ctrl H)

*** PRESS CRTL R ***

SOLID WASTE TRANSPORTATION MODEL

	14	15	16	17	18	19
9		CENTROID LINKS		DISTANCE	DIR. LINK ?	
10		-------- -----		--------	----------	
11		ORIGIN	DEST	KMS	(1=Y O=N)	
12		------	----	---	---------	
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						

sDsE& *** PRESS CTRL R TO ENTER THE ORIGIN AND DEST. ZONES THEN TYPE ***
Browsing; 26484 (Help: Ctrl H)

SOLID WASTE TRANSPORTATION MODEL

	14	15	16	17	18	19
9		CENTROID LINKS		DISTANCE	DIR. LINK ?	
10		-------- -----		--------	----------	
11		ORIGIN	DEST	KMS	(1=Y O=N)	
12		------	----	---	---------	
13						
14						
15		1	1			
16		1	2			
17		1	3			
18		1	4			
19		1	5			
20		2	1			
21		2	2			
22		2	3			
23		2	4			
24		2	5			
25		3	1			
26		3	2			
27		3	3			
28		3	4			

sDsE& *** PRESS CTRL R TO ENTER THE ORIGIN AND DEST. ZONES THEN TYPE ***
Browsing; 26484 (Help: Ctrl H)

SOLID WASTE TRANSPORTATION MODEL

	CENTROID LINKS		DISTANCE	DIR. LINK ?
	ORIGIN	DEST	KMS	(1=Y 0=N)
	1	1		
	1	2		
	1	3		
	1	4		
	1	5		
	2	1		
	2	2		
	2	3		
	2	4		
	2	5		
	3	1		
	3	2		
	3	3		
	3	4		

sFsG& *** PRESS CTRL R TO ENTER THE LINK DISTANCES ***

Browsing; 26484 (Help: Ctrl H)

```
LINKDIST
ENTER THE LINK DISTANCES (KMS) :

NODE : 1 TO NODE : 2
:
      45

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      0
NODE : 1 TO NODE : 3
:
      32

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      0
NODE : 1 TO NODE : 4
:
      25

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      1
      1
NODE : 1 TO NODE : 5
:
      37.5

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      0
NODE : 2 TO NODE : 3
:
      29.5

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      0
NODE : 2 TO NODE : 4
:
      22

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      0
NODE : 2 TO NODE : 5
:
      5

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      1
NODE : 3 TO NODE : 4
:
      7.5

IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      1
NODE : 3 TO NODE : 5
:
```

```
      24.5
IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      0
NODE : 4 TO NODE : 5
:
      13.5
IS THIS A DIRECT LINK ? (Type 1 for YES or 0 for NO)
:
      1
```

SOLID WASTE TRANSPORTATION MODEL

CENTROID LINKS		DISTANCE	DIR. LINK ?
ORIGIN	DEST	KMS	(1=Y 0=N)
1	1	0	0
1	2	45	0
1	3	32	0
1	4	25	1
1	5	37.5	0
2	1	45	0
2	2	0	0
2	3	29.5	0
2	4	22	0
2	5	5	1
3	1	32	0
3	2	29.5	0
3	3	0	0
3	4	7.5	1

& *** THE LINK DATA IS COMPLETE - PRESS CTRL E TO PROCEED ***

Browsing; 26484 (Help: Ctrl H)

SOLID WASTE TRANSPORTATION MODEL

*** PLEASE PRESS CTRL X TO CONTINUE ***

Browsing; 26484 (Help: Ctrl H)

```
DO YOU WANT TO CREATE A REPORT FOR DATABASE #2 ? (Y or N)
Y
REPORTS
1988/1/21  9:31


A REPORT NAMED SAMPLE HAS BEEN CREATED




DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX


WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE

:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE

DATE: 1988/1/21 9:31

DATABASE #2: LINK DATA

CENTROID LINKS		DISTANCE	DIR. LINK ?
ORIGIN	DEST	KMS	(1=Y 0=N)
1	1	0	0
1	2	45	0
1	3	32	0
1	4	25	1
1	5	37.5	0
2	1	45	0
2	2	0	0
2	3	29.5	0
2	4	22	0
2	5	5	1
3	1	32	0
3	2	29.5	0
3	3	0	0
3	4	7.5	1
3	5	24.5	0
4	1	25	1
4	2	22	0
4	3	7.5	1
4	4	0	0
4	5	13.5	1
5	1	37.5	0
5	2	5	1
5	3	24.5	0
5	4	13.5	1
5	5	0	0

```
                                        ***HIT ANY KEY TO PROCEED ***

DO YOU WANT TO CONTINUE EDITING DATABASES ? (Y or N)
Y


WHICH DATABASE DO YOU WANT TO BUILD/EDIT ?
ENTER: 1 FOR ZONE, POPULATION AND HAULAGE COST
       2 FOR LINK DATA
       3 FOR POTENTIAL SITE LOCATIONS
       4 FOR SITE ACCESS REQUIREMENTS
       5 TO RETURN TO PREVIOUS MENU
:
      3


                          SOLID WASTE TRANSPORTATION MODEL
                 28          29          30          31          32          33
    1
    2                              DATABASE #3
    3
    4                    POTENTIAL SITE LOCATIONS INPUT DATA
    5                    -----------------------------------
    6
    7                      # OF POTENTIAL SITES:
    8                                          -----
    9
   10          SITE NODE          SITE LINK
   11            NUMBER           LOCATION              DISTANCES
   12          ---------          ---------             ---------
   13             N          Ci          Cj       FROM Ci      FROM Cj
   14             -          --          --       -------      -------
   15
   16
   17
   18
   19
   20
NWCELL 7 32&                                                *** PRESS CRTL R ***
Browsing; 26484 (Help: Ctrl H)
```

```
                                SOLID WASTE TRANSPORTATION MODEL
                27              28              29              30              31              32
                                          # OF POTENTIAL SITES:
                                                                                  -----
 7
 8
 9
10                SITE NODE                     SITE LINK                          DISTANCES
11                NUMBER                        LOCATION                           ---------
12                ---------                     ---------
13                   N                Ci              Cj          FROM Ci         FROM Cj
14                   -                --              --          -------         -------
15
16
17
18
19
20
21
22
23
24
25
26
&                       *** PRESS CTRL - E TO USE EXISTING DATA, OTHERWISE TYPE <- ***
Browsing; 26484 (Help: Ctrl H)
```

SOLID WASTE TRANSPORTATION MODEL

27 28 29 30 31 32

OF POTENTIAL SITES: 1

SITE NODE NUMBER	SITE LINK LOCATION		DISTANCES	
N	Ci	Cj	FROM Ci	FROM Cj
-	--	--	-------	-------

sH& *** ENTER THE NUMBER OF POTENTIAL SITES THEN PRESS CRTL R ***
Browsing; 26484 (Help: Ctrl H)

SOLID WASTE TRANSPORTATION MODEL

FOR SITE NUMBER 1 ENTER SITE LINK IDENTIFICATION BY ORIGIN,DESTINATION (eg: 1,2)
:
2,5

2,5
ENTER THE DISTANCE TO THE SITE FROM NODE 2 (KMS):
:
2.4

```
                    SOLID WASTE TRANSPORTATION MODEL
          28          29          30          31          32          33
  2                      DATABASE #3
  3
  4            POTENTIAL SITE LOCATIONS INPUT DATA
  5            ----------------------------------
  6
  7              # OF POTENTIAL SITES:          1
  8                                            -----
  9
 10       SITE NODE          SITE LINK
 11         NUMBER           LOCATION              DISTANCES
 12       ---------          ---------           ---------
 13           N            Ci          Cj      FROM Ci     FROM Cj
 14           -            --          --      -------     -------
 15           1             2           5          2.4         2.6
 16
 17
 18
 19
 20
 21
&                  *** THIS DATABASE IS COMPLETE - TYPE CRTL E TO PROCEED ***
Browsing; 26484 (Help: Ctrl H)


                    SOLID WASTE TRANSPORTATION MODEL
          36          37          38          39          40          41
  1 ********************************************************************************
  2 *                                                                              *
  3 *                                                                              *
  4 *                                                                              *
  5 *                                                                              *
  6 *                                                                              *
  7 *                                                                              *
  8 *                                                                              *
  9 *                *** PLEASE PRESS CTRL X TO CONTINUE ***                       *
 10 *                                                                              *
 11 *                                                                              *
 12 *                                                                              *
 13 *                                                                              *
 14 *                                                                              *
 15 *                                                                              *
 16 *                                                                              *
 17 *                                                                              *
 18 *                                                                              *
 19 *                                                                              *
 20 ********************************************************************************

Browsing; 26484 (Help: Ctrl H)
```

```
DO YOU WANT TO CREATE A REPORT FOR DATABASE #3 ? (Y or N)
Y


A REPORT NAMED SAMPLE HAS BEEN CREATED




DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
N


DO YOU WANT TO CONTINUE EDITING DATABASES ? (Y or N)
Y


WHICH DATABASE DO YOU WANT TO BUILD/EDIT ?
ENTER: 1 FOR ZONE, POPULATION AND HAULAGE COST
       2 FOR LINK DATA
       3 FOR POTENTIAL SITE LOCATIONS
       4 FOR SITE ACCESS REQUIREMENTS
       5 TO RETURN TO PREVIOUS MENU
:
     5
    ENTER: 0 TO BUILD DATABASE
           1 TO USE MODEL 1
           2 TO USE MODEL 2/3
           3 TO EXIT
:
     1
WHICH SUB-OPTION OF MODEL1 DO YOU WANT ?
ENTER: A FOR SITE SELECTION
       B FOR CENTRE OF GENERATION
       C FOR POPULATION FORECAST
       D TO RETURN TO PREVIOUS MENU
B
CENTROID



THE BEST ZONE CENTROID IS:5
THE RANKED TE+KMS BY ZONE ARE:
    ZONE      TE-KMS
      5       39344.1676
      2       43353.5904
      4       53634.779
      3       73959.877
      1      103104.5138
CENTRE OF GENERATION SITE LOCATION IS:
CI=5    CJ=2
DISTANCE FROM CI: 2.378792881    DISTANCE FROM CJ: 2.621207119


HIT ANY KEY TO PROCEED
```

```
DO YOU WANT TO CREATE A REPORT FOR MODEL #1B ? (Y or N)
N
DO YOU WANT TO PROCEED TO MODEL #1C: POPULATION FORECASTS (Y/N) ?
N


DO YOU WANT TO RETURN TO THE PREVIOUS MENU OR EXIT (ENTER "R" or "E")
R
WHICH SUB-OPTION OF MODEL1 DO YOU WANT ?
ENTER: A FOR SITE SELECTION
       B FOR CENTRE OF GENERATION
       C FOR POPULATION FORECAST
       D TO RETURN TO PREVIOUS MENU
D
     ENTER: 0 TO BUILD DATABASE
            1 TO USE MODEL 1
            2 TO USE MODEL 2/3
            3 TO EXIT
:
      0


WHICH DATABASE DO YOU WANT TO BUILD/EDIT ?
ENTER: 1 FOR ZONE, POPULATION AND HAULAGE COST
       2 FOR LINK DATA
       3 FOR POTENTIAL SITE LOCATIONS
       4 FOR SITE ACCESS REQUIREMENTS
       5 TO RETURN TO PREVIOUS MENU
:
      3
                        SOLID WASTE TRANSPORTATION MODEL
              28          29          30          31          32          33
    1
    2                          DATABASE #3
    3
    4                POTENTIAL SITE LOCATIONS INPUT DATA
    5                ----------------------------------
    6
    7                  # OF POTENTIAL SITES:          1
    8                                                 -----
    9
   10          SITE NODE                SITE LINK
   11            NUMBER                 LOCATION                DISTANCES
   12          ---------                ---------               ---------
   13             N                Ci              Cj        FROM Ci     FROM Cj
   14             -                --              --        -------     -------
   15             1                 2               5          2.4         2.6
   16
   17
   18
   19
   20                                                          *** PRESS CRTL R ***
NWCELL 7 32&
Browsing; 26484 (Help: Ctrl H)
```

```
                    SOLID WASTE TRANSPORTATION MODEL
          27          28          29          30          31          32
 7                          # OF POTENTIAL SITES:           2
 8                                                        -----
 9
10                  SITE NODE          SITE LINK
11                    NUMBER           LOCATION                DISTANCES
12                  ---------          ---------               ---------
13                      N          Ci          Cj        FROM Ci      FROM Cj
14                      -          --          --        -------      -------
15                      1           2           5           2.4          2.6
16
17
18
19
20
21
22
23
24
25
26
sH&                *** ENTER THE NUMBER OF POTENTIAL SITES THEN PRESS CRTL R ***
Browsing; 26484 (Help: Ctrl H)

SITELOC




FOR SITE NUMBER 1 ENTER SITE LINK IDENTIFICATION BY ORIGIN,DESTINATION (eg: 1,2)
:
      2,5
ENTER THE DISTANCE TO THE SITE FROM NODE 2 (KMS):
:
      2.4


FOR SITE NUMBER 2 ENTER SITE LINK IDENTIFICATION BY ORIGIN,DESTINATION (eg: 1,2)
:
      2,5
ENTER THE DISTANCE TO THE SITE FROM NODE 2 (KMS):
:
      2.62
```

SOLID WASTE TRANSPORTATION MODEL

DATABASE #3

POTENTIAL SITE LOCATIONS INPUT DATA

OF POTENTIAL SITES: 2

SITE NODE NUMBER	SITE LINK LOCATION		DISTANCES	
N	Ci	Cj	FROM Ci	FROM Cj
1	2	5	2.4	2.6
2	2	5	2.62	2.38

& *** THIS DATABASE IS COMPLETE - TYPE CRTL E TO PROCEED ***

Browsing; 26484 (Help: Ctrl H)

SOLID WASTE TRANSPORTATION MODEL

*** PLEASE PRESS CTRL X TO CONTINUE ***

Browsing; 26484 (Help: Ctrl H)

DO YOU WANT TO CREATE A REPORT FOR DATABASE #3 ? (Y or N)
Y
REPORTS
1988/1/21 9:46

```
A REPORT NAMED SAMPLE HAS BEEN CREATED



DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX


WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:

WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE

DATE: 1988/1/2

DATABASE #3: SITE LOCATION DATA

OF POTENTIAL SITES: 2

SITE NODE NUMBER	SITE LINK LOCATION		DISTANCES	
N	Ci	Cj	FROM Ci	FROM Cj
1	2	5	2.4	2.6
2	2	5	2.62	2.38

```
DO YOU WANT TO CONTINUE EDITING DATABASES ? (Y or N)
Y


WHICH DATABASE DO YOU WANT TO BUILD/EDIT ?
ENTER: 1 FOR ZONE, POPULATION AND HAULAGE COST
       2 FOR LINK DATA
       3 FOR POTENTIAL SITE LOCATIONS
       4 FOR SITE ACCESS REQUIREMENTS
       5 TO RETURN TO PREVIOUS MENU
:
      4
ACCESS




WHAT IS THE ANALYSIS YEAR ?
:
      1987
WHAT IS THE AVG. ANNUAL INFLATION RATE ? (RETURN for 5% )

WHAT IS THE INTEREST RATE ? (RETURN for 10%)

WHAT IS THE AMMORTIZATION PERIOD ? (RETURN for 10 yrs)

ARE THE ABOVE VALUES OKAY ? (Y or N)
Y
CHNG
THIS PROCEDURE WILL TAKE A FEW MINUTES ...
```

```
THIS SITE REFERENCE NUMBER IS 1
WHAT IS THE TOTAL LENGTH OF THE ACCESS ROAD (KMS) ?
:
      3.5
IS ANY NEW CONSTRUCTION OF THE ACCESS ROAD REQUIRED (Y or N) ?
Y
ENTER THE LENGTH (KMS) OF NEW CONSTRUCTION FOR THE ACCESS ROAD:
:
      2.8
WHAT TYPE OF SURFACE WILL THE NEW ROAD HAVE ?

ENTER:    1 FOR GRAVEL
          2 FOR CHIP SEAL
          3 FOR PAVEMENT

:
      1
HOW MANY STRUCTURES ARE REQUIRED FOR THE NEW ROAD SECTION ?
:
      0
IS ANY RECONSTRUCTION OF EXISTING ROAD REQUIRED (Y or N) ?
N
IS ANY RESURFACING AND/OR UPGRADING OF EXISTING ROAD REQUIRED (Y or N)?
N
HOW MANY STRUCTURES ARE REQUIRED FOR THE EXISTING ROAD SECTION ?
:
      0
IS A HIGHWAY INTERCHANGE REQUIRED (Y or N)?
N
IS AT-GRADE INTERSECTION CONSTRUCTION/UPGRADING REQUIRED (Y or N)?
N
THIS SITE REFERENCE NUMBER IS 2
WHAT IS THE TOTAL LENGTH OF THE ACCESS ROAD (KMS) ?
:
      4.8
IS ANY NEW CONSTRUCTION OF THE ACCESS ROAD REQUIRED (Y or N) ?
N
IS ANY RECONSTRUCTION OF EXISTING ROAD REQUIRED (Y or N) ?
Y
ENTER THE LENGTH (KMS) OF RECONSTRUCTION OF EXISTING ROAD
:
      4.2
WHAT TYPE OF SURFACE WILL THE RECONSTRUCTED ROAD HAVE ?

ENTER:    1 FOR GRAVEL
          2 FOR CHIP SEAL
          3 FOR PAVEMENT

:
      2
IS ANY RESURFACING AND/OR UPGRADING OF EXISTING ROAD REQUIRED (Y or N)?
Y
ENTER THE LENGTH REQUIRED FOR RESURFACING/UPGRADING (KMS):
:
      .4
WHAT TYPE OF SURFACE WILL THE RESURFACED/UPGRADED ROAD HAVE ?

ENTER:    1 FOR GRAVEL
          2 FOR CHIP SEAL
          3 FOR PAVEMENT

:
      2
IS SHOULDER UPGRADING REQUIRED (Y or N)?
N
```

IS DITCHING WORK REQUIRED (Y or N)?
N
HOW MANY STRUCTURES ARE REQUIRED FOR THE EXISTING ROAD SECTION ?
:
0
IS A HIGHWAY INTERCHANGE REQUIRED (Y or N)?
N
IS AT-GRADE INTERSECTION CONSTRUCTION/UPGRADING REQUIRED (Y or N)?
Y

```
                    SOLID WASTE TRANSPORTATION MODEL
          36        37        38        39        40        41
 20 ********************************************************************
 21 *                                                                  *
 22 *    ************************************************************  *
 23 *    *                                                          *  *
 24 *    *                                                          *  *
 25 *    *                                                          *  *
 26 *    *                                                          *  *
 27 *    *                                                          *  *
 28 *    *                                                          *  *
 29 *    *              *** PRESS CTRL-E TO PROCEED ***             *  *
 30 *    *                                                          *  *
 31 *    *                                                          *  *
 32 *    *                                                          *  *
 33 *    *                                                          *  *
 34 *    *                                                          *  *
 35 *    *                                                          *  *
 36 *    *                                                          *  *
 37 *    ************************************************************  *
 38 *                                                                  *
 39 ********************************************************************

Browsing; 26484 (Help: Ctrl H)

        1 File(s) copied
                    SOLID WASTE TRANSPORTATION MODEL
          36        37        38        39        40        41
  1 ********************************************************************
  2 *                                                                  *
  3 *                                                                  *
  4 *                                                                  *
  5 *                                                                  *
  6 *                                                                  *
  7 *                                                                  *
  8 *                                                                  *
  9 *              *** PLEASE PRESS CTRL X TO CONTINUE ***             *
 10 *                                                                  *
 11 *                                                                  *
 12 *                                                                  *
 13 *                                                                  *
 14 *                                                                  *
 15 *                                                                  *
 16 *                                                                  *
 17 *                                                                  *
 18 *                                                                  *
 19 *                                                                  *
 20 ********************************************************************

Browsing; 26484 (Help: Ctrl H)
```

```
DO YOU WANT TO CREATE A REPORT FOR DATABASE #4 ? (Y or N)
Y
REPORTS
1988/1/21  9:57


A REPORT NAMED SAMPLE HAS BEEN CREATED




DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX


WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:

WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE

DATE: 1980/1/21 9:57

DATABASE #4: SITE ACCESS REQUIREMENTS DATA

*
*
*
*
*
*

ANALYSIS YEAR:	1987
COST BASE YEAR:	1986
AVERAGE ANNUAL INFLATION RATE:	5 %
INTEREST RATE:	10 %
AMMORTIZATION PERIOD:	10 yrs

SITE REF. NUMBERS	ACCESS ROAD LENGTH (KMS)			(0=na,1=gravel, 2=chip seal,3=pavement)		
N	NEW	RECONST.	RESURFAC	NEW	RECONST.	RESURFAC
1	2.8	0	0	1	0	0
2	0	4.2	0.4	0	2	2

CONSTRUCT/RECONSTRUCT BASE & SURFACE		RESURFACE /UPGRADE	SHOULDER UPGRADE	DITCHING WORK	STRUCTURES (number)	
NEW	EXISTING	EXISTING	EXISTING	EXISTING	NEW	EXISTING
1	0	0	0	0	0	0
0	1	1	0	0	0	0

OR

HIGHWAY INTERCHANGE	AT-GRADE INTERSECT.	ANNUAL SITE MAINTENANCE	
EXISTING	EXISTING	NEW	EXISTING
0	0	1	0
0	1	1	1

```
DO YOU WANT TO CONTINUE EDITING DATABASES ? (Y or N)
N
     ENTER: 0 TO BUILD DATABASE
            1 TO USE MODEL 1
            2 TO USE MODEL 2/3
            3 TO EXIT
:
      1
WHICH SUB-OPTION OF MODEL1 DO YOU WANT ?
ENTER: A FOR SITE SELECTION
       B FOR CENTRE OF GENERATION
       C FOR POPULATION FORECAST
       D TO RETURN TO PREVIOUS MENU
A

SITEOPTS
THIS PROCEDURE WILL TAKE A FEW MINUTES ...

                ACCESS ROAD              DELIVERY              TRANSPORT
     SITE #:       COST                   COST                  COST
     ------ -   -----------              --------              -----------
          1        75748.3                 50506.1             1.26254E+05
          2   2.36447E+05                  54229.8             2.90677E+05



                                                  *** HIT ANY KEY TO PROCEED ***

DO YOU WANT TO CREATE A REPORT FOR MODEL 1A ? (Y or N)
Y
REPORTS
1988/1/21  10:01


A REPORT NAMED SAMPLE HAS BEEN CREATED



DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX


WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE

DATE: 1988/1/21 10:01

MODEL 1A: SITE OPTIONS SELECTION MODEL REPORT

SITE #:	SITE LINKS CI	SITE LINKS CJ	DISTANCE FROM CI	DISTANCE FROM CJ	ACCESS ROAD LENGTH (KMS) NEW	ACCESS ROAD LENGTH (KMS) RECONSTR.	ACCESS ROAD LENGTH (KMS) RESURFACE
1	2	5	2.4	2.6	2.8	0	0
2	2	5	2.62	2.38	0	4.2	0.4

SITE #:	ANNUALIZED ACCESS ROAD COST	ANNUAL DELIVERY COST	TOTAL SITE TRANSPORT COST
1	75748.3	50506.1	1.26254E+05
2	2.36447E+05	54229.8	2.90677E+05

```
                                        ***HIT ANY KEY TO PROCEED ***

DO YOU WANT TO RETURN TO THE MENU FOR MODEL #1 OR EXIT ? (R or E)
R
WHICH SUB-OPTION OF MODEL1 DO YOU WANT ?
ENTER: A FOR SITE SELECTION
       B FOR CENTRE OF GENERATION
       C FOR POPULATION FORECAST
       D TO RETURN TO PREVIOUS MENU
C
                        SOLID WASTE TRANSPORTATION MODEL
              69          70          71          72          73          74
   45
   46
   47
   48                          MODEL 1C - POPULATION FORECASTS
   49
   50
   51                 POPULATION FORECAST PROCEDURES:
   52
   53                    1.       PROVINCIAL OVERALL GROWTH RATE
   54                    2.       PROVINCIAL URBAN/RURAL GROWTH RATES
   55                    3.       LINEAR PROJECTION OF HISTORIC DATA
   56                    4.       ZONAL OVERALL GROWTH RATE
   57                    5.       ZONAL URBAN/RURAL GROWTH RATES
   58
   59
   60
   61
   62
   63
   64                                                                  1
sL&                      *** ENTER DESIRED PROCEDURE NUMBER THEN PRESS CTRL R ***
Browsing; 26484 (Help: Ctrl H)
```

SOLID WASTE TRANSPORTATION MODEL

74	75	76	77	78	79
			OVERALL GROWTH RATE(%)		1.1

FUTURE PROJECTED POPULATION

1987	1988	1991	1996	2001	2006

*** ENTER GROWTH RATE, RETURN, THEN PRESS CTRL R ***

sU&
Browsing; 26484 (Help: Ctrl H)

PROJECTION1

```
                    SOLID WASTE TRANSPORTATION MODEL
          74          75          76          77          78          79
 12
 13                                FUTURE PROJECTED POPULATION
 14       1987        1988        1991        1996        2001        2006
 15       ----        ----        ----        ----        ----        ----
 16       1047        1059        1094        1156        1221        1289
 17       2918        2950        3048        3220        3401        3592
 18        653         660         682         721         761         804
 19        760         769         794         839         886         936
 20       1034        1046        1081        1141        1205        1273
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
&                                                  *** PRESS CTRL E TO PROCEED ***
Browsing; 26484 (Help: Ctrl H)

        1 File(s) copied
                    SOLID WASTE TRANSPORTATION MODEL
          36          37          38          39          40          41
  1 ********************************************************************************
  2 *                                                                              *
  3 *                                                                              *
  4 *                                                                              *
  5 *                                                                              *
  6 *                                                                              *
  7 *                                                                              *
  8 *                                                                              *
  9 *                *** PLEASE PRESS CTRL X TO CONTINUE ***                       *
 10 *                                                                              *
 11 *                                                                              *
 12 *                                                                              *
 13 *                                                                              *
 14 *                                                                              *
 15 *                                                                              *
 16 *                                                                              *
 17 *                                                                              *
 18 *                                                                              *
 19 *                                                                              *
 20 ********************************************************************************

Browsing; 26484 (Help: Ctrl H)
```

```
DO YOU WANT TO CREATE A REPORT FOR THIS POPULATION PROJECTION ? (Y or N)
Y
REPORTS
1988/1/21  10:06


A REPORT NAMED SAMPLE HAS BEEN CREATED




DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX



WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:

WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE DATE: 1988/1/21 10:06

MODEL #1C: POPULATION FORECAST OPTIONS REPORT

PROVINCIAL OVERALL GROWTH RATE (%): 1.1

ZONES	PRESENT 1986	1987	1988	FUTURE PROJECTED POPULATION 1991	1996	2001	2006
1	1036	1047	1059	1094	1156	1221	1289
2	2886	2918	2950	3048	3220	3401	3592
3	646	653	660	682	721	761	804
4	752	760	769	794	839	886	936
5	1023	1034	1046	1081	1141	1205	1273

```
WHICH FORECAST YEAR DO YOU WANT TO USE ?
      ENTER       1986
                  1987
                  1988
                  1991
                  1996
                  2001
                   or
                  2006

(NOTE - Entering 1986 will recalculate database #1 values to original
        year if the population has already been changed to a forecast
        year by running this procedure.)

:
      2001

WHAT IS THE ANALYSIS YEAR ?
:
      2001
WHAT IS THE AVG. ANNUAL INFLATION RATE ? (RETURN for 5% )

WHAT IS THE INTEREST RATE ? (RETURN for 10%)

WHAT IS THE AMMORTIZATION PERIOD ? (RETURN for 10 yrs)

ARE THE ABOVE VALUES OKAY ? (Y or N)
Y
CHNG
THIS PROCEDURE WILL TAKE A FEW MINUTES ...

                    SOLID WASTE TRANSPORTATION MODEL
              36        37        38        39        40        41
   20 ********************************************************************************
   21 *                                                                              *
   22 *    ************************************************************************  *
   23 *    *                                                                      *  *
   24 *    *                                                                      *  *
   25 *    *                                                                      *  *
   26 *    *                                                                      *  *
   27 *    *                                                                      *  *
   28 *    *                                                                      *  *
   29 *    *              *** PRESS CTRL-E TO PROCEED ***                         *  *
   30 *    *                                                                      *  *
   31 *    *                                                                      *  *
   32 *    *                                                                      *  *
   33 *    *                                                                      *  *
   34 *    *                                                                      *  *
   35 *    *                                                                      *  *
   36 *    *                                                                      *  *
   37 *    ************************************************************************  *
   38 *                                                                              *
   39 ********************************************************************************

Browsing; 26484 (Help: Ctrl H)
```

```
      1 File(s) copied
                        SOLID WASTE TRANSPORTATION MODEL
              36          37          38          39          40          41
    1 ************************************************************************
    2 *                                                                      *
    3 *                                                                      *
    4 *                                                                      *
    5 *                                                                      *
    6 *                                                                      *
    7 *                                                                      *
    8 *                                                                      *
    9 *                *** PLEASE PRESS CTRL X TO CONTINUE ***               *
   10 *                                                                      *
   11 *                                                                      *
   12 *                                                                      *
   13 *                                                                      *
   14 *                                                                      *
   15 *                                                                      *
   16 *                                                                      *
   17 *                                                                      *
   18 *                                                                      *
   19 *                                                                      *
   20 ************************************************************************

Browsing; 26484 (Help: Ctrl H)


THE POPULATION DATA FOR 2001 HAS BEEN USED TO RECALCULATE DATABASE #1 (ZONE,POPU
      LATION AND HAULAGE COST DATA) AND THE ACCESS ROAD CONSTRUCTION COSTS HAVE
      BEEN ADJUSTED ACCORDINGLY

DO YOU WANT TO CREATE A REPORT FOR DATABASE #1 USING THE 2001 DATA? (Y or N):
Y
REPORTS
1988/1/21  10:14


A REPORT NAMED SAMPLE HAS BEEN CREATED




DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX



WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE

DATE: 1900/1/21 10:14

DATABASE #1: POPULATION, ZONE, AND HAULAGE COST DATA

POPULATION BASE YEAR:	2001	
AVERAGE ANNUAL INFLATION RATE:	5	%
NUMBER OF ZONES:	5	
SOLID WASTE PER CAPITA DAY:	1.36	kg
AVERAGE LINE HAUL PAYLOAD:	4	te
AVERAGE HAULAGE COST PER KM.:	1.67	$

ZONES	POPULATION	te/DAY	te/WK	te/YR	TRIPS/WK	TRIPS/YEAR
1	1221	1.66056	11.6239	606.104	3	156
2	3401	4.62536	32.3775	1688.26	9	468
3	761	1.03496	7.24472	377.76	2	104
4	886	1.20496	8.43472	439.81	3	156
5	1205	1.6388	11.4716	598.162	3	156

```
DO YOU WANT TO RETURN TO THE MENU FOR MODEL #1 OR EXIT (ENTER "R" or "E")
R
WHICH SUB-OPTION OF MODEL1 DO YOU WANT ?
ENTER: A FOR SITE SELECTION
       B FOR CENTRE OF GENERATION
       C FOR POPULATION FORECAST
       D TO RETURN TO PREVIOUS MENU
A


SITEOPTS
THIS PROCEDURE WILL TAKE A FEW MINUTES ...

                ACCESS ROAD          DELIVERY          TRANSPORT
     SITE #:       COST               COST              COST
     ------ -  -----------          --------          -----------
          1        75748.3             55959.7          1.31708E+05
          2  2.36447E+05                60399          2.96846E+05


                                                *** HIT ANY KEY TO PROCEED ***

DO YOU WANT TO CREATE A REPORT FOR MODEL 1A ? (Y or N)
Y
REPORTS
1988/1/21  10:18

A REPORT NAMED SAMPLE HAS BEEN CREATED




DO YOU WANT TO USE THE REPORT AT THIS TIME ? (Y or N)
Y
REPAUX


WHAT DO YOU WANT TO DO ?

ENTER:    1   TO VIEW THE REPORT
          2   TO PRINT THE REPORT
          3   TO CONTINUE TO THE NEXT PROCEDURE
:
      2
```

SOLID WASTE TRANSPORTATION MODEL

RUN NAME: SAMPLE

DATE: 1988/1/21 10:10

MODEL 1A: SITE OPTIONS SELECTION MODEL REPORT

SITE #:	SITE LINKS CI	SITE LINKS CJ	DISTANCE FROM CI	DISTANCE FROM CJ	ACCESS ROAD LENGTH (KMS) NEW	ACCESS ROAD LENGTH (KMS) RECONSTR.	ACCESS ROAD LENGTH (KMS) RESURFACE
1	2	5	2.4	2.6	2.8	0	0
2	2	5	2.62	2.38	0	4.2	0.4

SITE #:	ANNUALIZED ACCESS ROAD COST	ANNUAL DELIVERY COST	TOTAL SITE TRANSPORT COST
1	75748.3	55959.7	1.31708E+05
2	2.36447E+05	60399	2.96846E+05

```
DO YOU WANT TO RETURN TO THE MENU FOR MODEL #1 OR EXIT ? (R or E)
R
WHICH SUB-OPTION OF MODEL1 DO YOU WANT ?
ENTER: A FOR SITE SELECTION
       B FOR CENTRE OF GENERATION
       C FOR POPULATION FORECAST
       D TO RETURN TO PREVIOUS MENU
D
     ENTER: 0 TO BUILD DATABASE
            1 TO USE MODEL 1
            2 TO USE MODEL 2/3
            3 TO EXIT
:
       2
1 1 1 1 1 1 1 1



PLEASE WAIT A MINUTE OR TWO . . .
PARTEST
1
1988/1/21  10:20
```

```
WHICH SITE DO YOU WANT TO CONSIDER FOR THIS RUN ? (ENTER THE SITE # 1 2)
:
      1
FOR ZONE 1 ENTER THE NUMBER OF LINKS:
:
      4
FOR LINK 1 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      17,120
FOR LINK 2 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      12,60
FOR LINK 3 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      8,100
FOR LINK 4 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      14,90
FOR ZONE 2 ENTER THE NUMBER OF LINKS:
:
      5
FOR LINK 1 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      10,200
FOR LINK 2 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      50,195
FOR LINK 3 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      18,260
FOR LINK 4 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      22,175
FOR LINK 5 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      11,175
FOR ZONE 3 ENTER THE NUMBER OF LINKS:
:
      4
FOR LINK 1 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      1,60
FOR LINK 2 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      1.5,20
FOR LINK 3 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      2,20
FOR LINK 4 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      6,90
FOR ZONE 4 ENTER THE NUMBER OF LINKS:
:
      4
FOR LINK 1 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      7,50
FOR LINK 2 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      4,30
FOR LINK 3 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
```

```
      3.5,20
FOR LINK 4 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      9,135
FOR ZONE 5 ENTER THE NUMBER OF LINKS:
:
      6
FOR LINK 1 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      1.7,50
FOR LINK 2 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      1.4,45
FOR LINK 3 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      2,40
FOR LINK 4 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      2.5,45
FOR LINK 5 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      3.5,60
FOR LINK 6 ENTER THE TOTAL ROAD DISTANCE,TOTAL HOUSEHOLDS:
:
      3.0,70
DO YOU WANT TO CONSIDER A TRANSFER STATION FOR ANY OF THE ZONES ?
 (Y or N):
N
REPORT2
1988/1/21  10:24
WHICH ZONES DO YOU WISH TO REPORT ?

ENTER  - DESIRED ZONE #s 1,2,3,. . .etc.
       - " 99 " to report all zones
       -  " 0 " for no zone reports
:
      1
DO YOU WANT A LIST OF OPTION DESCRIPTIONS ? (Y or N)
N
REPORTS HAVE BEEN CREATED FOR THE CHOSEN ZONES . . . DO YOU WANT TO
PRODUCE THEM AT THIS TIME ? (Y or N):
```

Y

SOLID WASTE TRANSPORTATION MODEL

COMMISSION: SAMPLE1 ZONE # 1 SITE # 1 DATE: 1988/1/21 10:24

MODEL 2: COLLECTION MODEL

SYSTEM COST REPORT

COSTS	OPTIONS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CURBSIDE COLLECTION TO DISPOSAL SITE:																				
Collection Cost:	494	544	591	776	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	1555	1423	743	732	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	206	61	36	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIRECT USER DELIVERY TO DISPOSAL SITE:																				
User Delivery Cost:	0	0	0	0	16769	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONTAINER SITE TO DISPOSAL SITE:																				
Collection Cost:	0	0	0	0	0	494	494	544	494	544	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	0	0	0	0	0	143	143	131	143	131	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	0	0	0	0	0	206	206	61	206	61	0	0	0	0	0	0	0	0	0	0
User Delivery Cost:	0	0	0	0	0	0	0	0	0	0	1538	1538	1538	1538	1538	0	0	0	0	0
Container Line Haul Cost:	0	0	0	0	0	372	393	393	827	827	319	341	372	393	827	0	0	0	0	0
Container Load/Unload Cost:	0	0	0	0	0	31	33	33	69	69	59	57	31	33	69	0	0	0	0	0
TRANSFER STATION TO DISPOSAL SITE:																				
Collection Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Haul Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unloading Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
User Delivery Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transfer Station Line Haul Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transfer Station Load/Unload Cost:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL SYSTEM COST (WEEKLY):	2335	2028	1370	1544	16769	1325	1348	1162	1818	1631	1916	1936	1941	1964	2434	0	0	0	0	0

DO YOU WANT A COST SUMMARY BY ZONE (Y or N) ?
Y

SOLID WASTE TRANSPORTATION MODEL

COMMISSION: SAMPLE1

DATE: 1988/1/21 10:24

SUMMARY OF ANNUAL COSTS FOR EACH SYSTEM OPTION BY ZONE ($)

ZONES	POP	LEAST COST	OPTIONS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1221	0	121420	105469	71260	80282	871969	68886	70111	60410	94516	84815	99653	100666	100923	102149	126554	0	0	0	0	0
2	3401	3	133096	103021	85988	108238	320502	127326	127573	98455	127804	98685	222599	222634	221506	221753	221984	0	0	0	0	0
3	761	3	58733	45167	27643	31542	314259	41000	41088	34132	59576	51819	55788	56464	56244	57132	74820	0	0	0	0	0
4	886	3	57098	45036	26872	32128	248964	43271	43873	34746	55877	46750	61332	61722	61098	61700	73704	0	0	0	0	0
5	1205	3	42999	32067	27419	33610	102213	43409	43661	33060	48689	38088	72410	72451	71330	71582	76610	0	0	0	0	0

POPULATION YEAR: 2001
ANALYSIS YEAR: 2001
TRANSFER STATION ZONE # 0
OTHER ZONES USING TRANSFER STATION

0
" DO YOU WANT TO RE-RUN THE MODEL USING A DIFFERENT SITE ? (Y or N)
N
DO YOU WANT TO RE-RUN THE MODEL USING A POPULATION PROJECTION ? (Y or N)
N
DO YOU WANT TO RETURN TO THE MENU FOR MODEL #1 OR EXIT (ENTER "R" or "E")
E

```
                    SOLID WASTE TRANSPORTATION MODEL
            21          22          23          24          25          26
   22 ********************************************************************************
   23 *                                                                              *
   24 *                                                                              *
   25 *                                                                              *
   26 *                SOLID WASTE TRANSPORTATION COST MODEL                         *
   27 *                                                                              *
   28 *                                                                              *
   29 *                                                                              *
   30 *                                                                              *
   31 *                NOW CLOSING SPREADSHEET DATABASE.....                         *
   32 *                                                                              *
   33 *                                                                              *
   34 *                                                                              *
   35 *                                                                              *
   36 *                                                                              *
   37 *                                                                              *
   38 *                                                                              *
   39 *                                                                              *
   40 *                                                  *** PRESS CRTL E *** *
   41 ********************************************************************************

Browsing: 26484 (Help: Ctrl H)

        1 File(s) copied
E



1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1
ENTER:    1 TO EXIT TO APL
          2 TO EXIT TO DOS

:
      2

C:\APL>cd\

C:\>
C:\>QUIT

C:\>cd\dbase

C:\DBASE>lo

C:\DBASE>cls

C:\DBASE>cd\

C:\>
C:\>
```